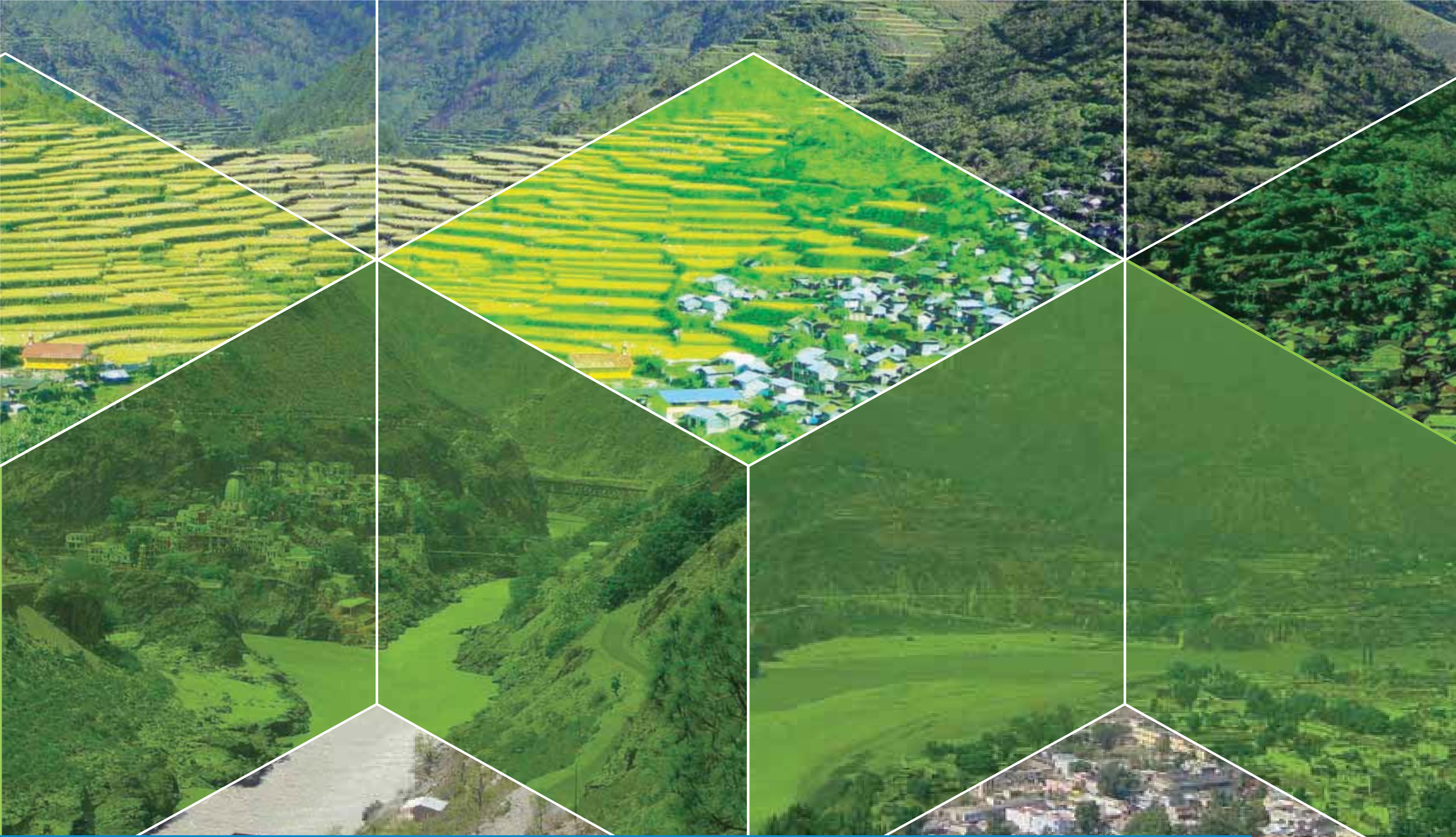

SUSTAINABLE LAND MANAGEMENT IN ASIA
INTRODUCING THE LANDSCAPE APPROACH

ASIAN DEVELOPMENT BANK

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ADB recognizes "China" as the People's Republic of China and "Vietnam" as Viet Nam.
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Foreword

The Asian Development Bank (ADB) has been at the forefront in supporting developing member countries in Asia and the Pacific to improve agricultural production, protect ecological resources, combat desertification, improve water resources management, and alleviate poverty. While member countries have applied different approaches, and demonstrated a variety of investment priorities, the overall objective has always been to ensure that lands are used in a sustainable manner.

For example, in the People's Republic of China (PRC), ADB and the Global Environment Facility (GEF) have been leading the PRC-GEF Partnership on Land Degradation in Dryland Ecosystems, in close cooperation with the Government of the PRC, the World Bank, and the International Fund for Agricultural Development. Since the start of the partnership in 2004, the program has introduced significant changes in the way farmers and other stakeholders view and benefit from evolving approaches to sustainable land management practices within their "landscape."

To land-based people, the "landscape" represents their perspective: it is what is meaningful to them, it is what affects them, and it is where, in one way or another, they can exercise some control. But outsiders also make demands on its resources. The landscape approach acknowledges this imprecise overall scale, and the often conflicting demands on space—and, consequently, the fact that planners must juggle with, and optimize the use of, the various resources to satisfy the needs and requirements of different stakeholders. The approach complements the traditional watershed management approach to overcome hydrological boundaries, its often top-down nature, and challenges to bring all stakeholders and sectors together.

This introduction to the landscape approach has provided a platform for a wide-ranging discussion about these issues, but has simultaneously opened up the opportunity for a discussion about sustainable land management (SLM) in the context of the landscape as a whole. While the landscape approach encompasses much more than the land's natural resources, it does embrace SLM as one of its key technical treatments, and encourages us to look at SLM and its role at various scales.

Thus, this document takes four widespread, and apparently quite different, forms of SLM—namely, participatory forest management, terraces, conservation agriculture, and homegardens—and examines each in some detail. But it also shows how each is integral to the landscape. All have elements of traditional knowledge; all are acknowledged by specialists to be of value to ecosystems and to climate change adaptation and mitigation, as well as contributing to the local and regional economy. Perhaps the main lesson, though, is that they (and the many other types of SLM) are linked, and, hence, the metaphor of the Russian doll—where different forms of SLM fit into each other, building up to conservation of the overall landscape. What may be the most important new element of the landscape approach is to help us appreciate "the organic living whole" rather than focusing too closely on the constituent parts in isolation.

Through this publication, ADB aspires to further strengthen the knowledge and awareness of the landscape approach, and hence facilitate the integration of key elements into cooperation programs with its developing member countries.

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Photos courtesy of William Critchley.

Abbreviations

ADB	Asian Development Bank
CA	conservation agriculture
ELD	Economics of Land Degradation
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
IEM	integrated ecosystem management
IPCC	Intergovernmental Panel on Climate Change
JFM	joint forest management
LDFA	land degradation focal area
Pg	petagram (equivalent to a billion tons)
PRC	People’s Republic of China
REDD/REDD+	(see glossary)
SALT	Sloping Agricultural Land Technology
SLM	sustainable land management
TEES-test	(see glossary)
UNEP	United Nations Environment Programme
WOCAT	World Overview of Conservation Approaches and Technologies

Glossary of Terms

Adaptation: *a process of responsive change that improves the ability of a socioeconomic system to achieve desired sustainability goals.* (O'Connell et al. 2015)

Agrobiodiversity: *the variability among living organisms associated with the cultivation of crops and rearing of animals, and the ecological complexes of which those species are part. This includes diversity between, and within, species and of ecosystems.* (McNeely and Scherr 2003)

Agroforestry: *a collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, rotation or both; there are usually both ecological and economic interactions between the trees and other components of the system.* (Lundgren 1982)

Conservation agriculture: *an approach to managing agro-ecosystems for improved and sustained productivity, increased profits, and food security while preserving and enhancing the resource base and the environment. Conservation agriculture is characterized by three linked principles: (i) continuous minimum mechanical soil disturbance, (ii) permanent organic soil cover, and (iii) diversification of crop species grown in sequences and/or associations.* (Conservation Agriculture at www.fao.org/ag/ca/)

Climate resilience: *the capacity of a socio-ecological system to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.* (Intergovernmental Panel on Climate Change 2014a)

Climate-smart agriculture (1): *agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gasses (mitigation), and enhances achievement of national food security and development goals.* (FAO 2010a)

Climate-smart agriculture (2): *a set of strategies that can help meet [the challenges of climate change] by increasing resilience to weather extremes, adapting to climate change, and decreasing agriculture's greenhouse gas emissions.* (Steenwerth et al. 2014)

Desertification: *land degradation in arid, semi-arid, and dry subhumid areas, resulting from various factors, including climate variations and human activity.* (United Nations Convention to Combat Desertification 1994)

Ecosystem: *a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit. Humans are an integral part of ecosystems.* (Millennium Ecosystem Assessment 2005)

Ecosystem approach (integrated ecosystem approach): *a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way.* (Convention on Biological Diversity 2004)

Ecosystem services: *the benefits people obtain from ecosystems. Classified as provisioning services, regulating services, cultural services, and supporting services.* (Millennium Ecosystem Assessment 2005)

Enrichment planting: *planting of economically and/or environmentally beneficial species to improve natural vegetation.* (Cadiz et al. 2001)

Global environmental benefits: *global environmental benefits are specific to each of the focal areas of the Global Environment Facility. In the land degradation focal area, these include* (i) *improved provision of agro-ecosystem and forest ecosystem goods and services; (ii) mitigated/avoided greenhouse gas emissions and increased carbon sequestration in production landscapes; (iii) reduced vulnerability of agro-ecosystems and forest ecosystems to climate change and other human-induced impacts; (iv) conservation and sustainable use of biodiversity in productive landscapes; and (v) reduced pollution and siltation of international waters.* (GEF Global Environmental Benefits at www.thegef.org/documents/global-environmental-benefits)

Green economy: *an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient, and socially inclusive.* (UNEP 2011)

Landscape approaches: *landscape approaches seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals.* (Sayer et al. 2013)

Land degradation: *the reduction in the capacity of the land to provide ecosystem goods and services, over a period of time, for its beneficiaries.* (FAO 2013a)

Natural capital: *the stock of natural assets and resources that provide ecosystem services, such as food, water, timber, pollination of crops and absorption of human waste products like carbon dioxide.* (ADB and WWF 2012)

Payment for ecosystem services: *a transaction in which a well-defined ecosystem service, or a form of land use likely to secure that service, is bought from an ecosystem service provider on the condition that the provider continues to supply that service.* (Adapted from Wunder 2005)

Public–private partnerships: *arrangements between the public and private sectors whereby part of the services or works that fall under the responsibilities of the public sector are provided by the private sector, with clear agreement on shared objectives for delivery of public infrastructure and/or public services.* (World Bank at http://ppp.worldbank.org/public-private-partnership)

REDD: *reducing emissions from deforestation and forest degradation in developing countries.* (UNEP 2014)

REDD+: *reducing emissions from deforestation and forest degradation in developing countries and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks.* (UNEP 2014)

Resilience: *the ability of a socioeconomic system to absorb disturbance and reorganize, so as to retain essentially the same function and structure.* (O'Connell et al. 2015)

Sustainable land management: *a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management to meet rising food and fiber requirements while sustaining ecosystem services and livelihoods.* (World Bank 2006)

TEES-test: *a preliminary filter for appropriateness of sustainable land management interventions or innovations, assessing technical performance, economic returns, environmental friendliness, and social acceptability.* (Critchley 2007)

Water harvesting: *the collection of runoff for its productive use***.** (Critchley and Siegert 1991)

Introduction: Addressing Renewed Challenges

1

Since the 1960s, there have been very significant transformations in the rural areas of Asia. But while food production has increased remarkably, and poverty levels have fallen considerably, there remain problems of hunger, nutrition, and land degradation. These challenges need to be confronted anew. This introduction briefly looks at achievements, outstanding priorities, and how green growth can help set the agenda for revitalizing landscapes.

Historical Progress: But Problems Persist

Asia's progress in terms of feeding her people and addressing land degradation over the last 50 years is, in many ways, remarkable. Yet severe problems remain—and a new one, climate change, has emerged. The "green revolution" was an extraordinary achievement against the backdrop of hunger, malnutrition, and droughts in the 1960s. It was considered as the first major expression of the application of modern science to Asia's agricultural problems (ADB 2000). It was not sub-Saharan Africa's plight that was in the spotlight then, but Asia's, and specifically India's. Plant breeding, and the subsequent rapid spread of high-yielding varieties, combined with new expanses under irrigation and the use of agrochemicals, led to a more than doubling of yields in Asia between 1970 and 1995.

The "green revolution" was an extraordinary achievement against the backdrop of hunger, malnutrition, and droughts in the 1960s. It was considered as the first major expression of the application of modern science to Asia's agricultural problems.

Criticisms of the green revolution have centered on associated environmental degradation—especially through intensive use of agrochemicals, and increased rural–urban income inequality. But the achievements of raising yields and feeding people surely outweighed the environmental and socioeconomic negatives (International Food Policy Research Institute 2002). There was an urgent imperative to feed millions of people, and that had to be the initial priority. As Asia's rural population continues to grow, enormous pressures are exerted not only on rural Asia's natural resources but more so on its quality of life, mainly because of the lack of development of basic social institutions such as health and education services (Bloom et al. 2001).

Fast-forward to the Millennium Development Goals, and the global target of halving extreme poverty by the end of 2015 was already met 5 years ahead of schedule—with the greatest achievements being realized in Asia. However, though hunger has also been reduced with agricultural and economic progress in East and Southeast Asia, there are still over 800 million people undernourished globally (FAO, International Fund for Agricultural Development, and World Food Programme 2014). The Asian Development Bank's (ADB) developing member countries remain home to the world's largest number (two-thirds) of hungry and malnourished people, despite the profound positive impacts of development and economic transformation on poverty, standards of living, and overall prosperity in the past decades (ADB 2015); while the percentage may be greater in Sub-Saharan Africa, the majority of the malnourished live in Asia. Beddington et al. (2011) note the bitter irony that the number of people in the world who go hungry is almost exactly matched by the number who overconsume. Poor nutrition—e.g., lack

Two-thirds of the world's hungry people are found in Asia.

of vitamin A—and food wastage throughout the chain from field to table are associated problems. Nevertheless, the better news is that it is estimated that annual world agricultural production has risen at 2.2% annually between 1997 and 2007 (Beddington et al. 2011).

There is now growing recognition of the complex relationships between sound management of ecosystems, the determinants of poverty, and the effectiveness of poverty reduction efforts. In 2007, ADB and the International Union for Conservation of Nature collaborated on a study of experiences and best practices regarding the links that bind together poverty, human health, and ecosystems management in Asia (Steele et al. 2007).

Climate change, in the meantime, has raised its head. Hardly mentioned or noted 25 years ago, climate change has now become a severe complicating factor, interfering with all sectors of the environment and with development. The most recent Intergovernmental Panel on Climate Change (IPCC) report on Impacts, Adaptation, and Vulnerability (Working Group II), looking at Asia, identifies "increased risk of drought-related water and food shortage causing malnutrition" and assigns it a "high confidence" level. Specifically, it may imply negative impacts on aggregate wheat yields in South Asia beyond increases due to improved technology (IPCC 2014a). The overall IPCC synthesis report for policy makers highlights various examples of appropriate responses. These include new crop varieties and breeds of animals, water-saving technologies, soil conservation, community-based natural resource management and, specifically, conservation agriculture (IPCC 2014b).

Green Growth: Facing Current Challenges

Climate change has now become a severe complicating factor, interfering with all sectors of the environment and with development.

Green growth is pursuit of economic growth that fosters environmentally sustainable and socially inclusive development (OECD 2011). The "Green Growth Strategy" of the Asian Development Bank (ADB) aims to promote a transition to green growth, while addressing the causes and consequences of climate change (ADB 2013). The five key, and interlinked, challenges that the strategy addresses are: (i) climate change, (ii) food and energy and water, (iii) rapid urbanization, (iv) natural resource degeneration, and (v) environmental governance.

It is easy to see the logic behind the selection of these areas, given the foregoing discussion in the introduction. Forthcoming from these challenges, four mutually supportive environmental operational directions have been identified: (i) promoting a shift to sustainable infrastructure; (ii) investing in natural capital (reverse ongoing decline to ensure environmental goods and services can sustain future economic growth and well-being, build climate resilience, and contribute to carbon sequestration); (iii) strengthening environmental governance and management capacity; and (iv) responding to the climate change imperative.

It is instructive to note the parallels with the United Nations Environment Programme's (UNEP) "Green Economy," defined as "an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP 2011). Green growth strategies are instruments to achieving a "green economy." Although there is no "one-size-fits-all" prescription for promoting greener growth, "maintaining natural capital such as forests, biodiversity, freshwater, and coastal and marine ecosystems is essential to making 'green economies' a reality" (ADB and WWF 2012). Sustainably managing its natural capital in the interests of long-term development is a critical challenge in Asia—it is particularly important for the rural poor, whose livelihoods and ability to cope with natural disasters directly depend on the availability of local ecosystem services. However, since the 1990s, the state of ecosystems in Asia has been declining. Conversion of primary forests to agricultural land or monoculture plantations has, for example, resulted in a significant decrease in the more biologically diverse "old growth" forests, which provide essential services such as carbon storage and clean water (ADB and WWF 2012).

Sustainably managing its natural capital in the interests of long-term development is a critical challenge in Asia.

Furthermore, ADB's *Operational Plan for Agriculture and Natural Resources* (ADB 2015) focuses on four priority areas: (i) increasing the productivity and reducing pre- and postharvest losses of food harvests; (ii) improving market connectivity and value chain linkages; (iii) enhancing food safety, quality, and nutrition; and (iv) enhancing management and climate resilience of natural

Urbanization commonly means the loss of productive agricultural land.

resources. While sustainable land management (SLM) and the landscape approach contribute, in one way or another, to each, it is the fourth area to which they are central. Management (by definition) and climate resilience are firmly embedded in SLM, and can be enhanced and scaled-up by adopting a landscape approach.

Countries in Asia are taking the lead in implementing green growth by reforming economic incentives, promoting a more inclusive and adaptive governance, and pursuing and investing in green strategies and policy reforms that help align economic growth strategies with the objective of sustainable development (ADB 2012). What is most important here is evidence of the emerging international consensus that the major environmental and developmental challenges of our times are interlinked.

This current paper focuses on the rural areas of Asia and sets out how the "landscape approach," underpinned by SLM, can contribute to overcoming these key challenges, and how the approach fits neatly into the operational directions of ADB—and all those agencies that strive for the same goals.

Changing Perspectives: Paths Leading to a New Approach in Land Management

2

Over the last quarter century, there have been paradigm shifts in the thinking about land management—away from the conventional "command-and-control" top-down systems that took research recommendations and imposed them on land users. The earliest of these changes concerned recognizing the human face of the issue; thus, the importance of indigenous knowledge and tradition, the crucial role of women, and the potential of participatory planning and implementation. More recently, the impact of climate change and its implications for land management have become clearer. We look here at 10 important new perspectives where emphasis has been placed, and these then lead us toward the landscape approach discussed in Chapter 3.

Controlling Land Degradation: From Soil Conservation to Sustainable Land Management

Concerns with the devastating impacts of land degradation both on the environment and on rural poverty led to the adoption of the United Nations Convention to Combat Desertification, which emerged from the 1992 United Nations Conference on Environment and Development meeting, the "Rio Earth Summit." The word "desertification" was chosen rather than "land degradation" presumably because of its more powerful visual message. While desertification is defined by the United Nations Convention to Combat Desertification as "land degradation in arid,

Women play a crucial role in farm production—such as these women in India (left) and Thailand (right).

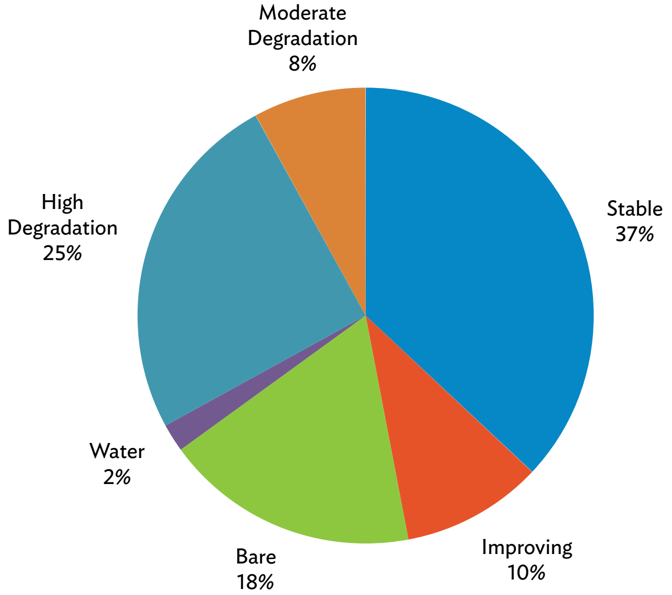
semi-arid, and dry subhumid areas, resulting from various factors, including climate variations and human activity," the popular perception, usually inaccurate, is that of "expanding deserts." Thus confusion was introduced from the beginning, and it continuously needs to be explained.

The main component of land degradation is soil erosion, which robs soil of its fertility and water holding capacity, and reduces its biodiversity: the soil's health suffers. Sadly, the quality and quantity of arable land across Asia is continuously diminishing, thereby affecting large segments of the population (Bai et al. 2008). For example, (i) in India, nearly half of the country's land is degraded as a result of soil erosion, rising salinity, and pesticide contamination; (ii) in the People's Republic of China (PRC), the area of arable land continues to fall, despite extensive land restoration projects, because of erosion and pollution; and (iii) in Viet Nam and Thailand, intensive farming has contributed to high rates of decline in agricultural soil quality (Howes and Wyrwoll 2012a). From a climate change perspective, land degradation releases carbon into the atmosphere. Simultaneously, the land becomes less resilient as it loses its organic matter and thus its structure and buffering capacity. From an economic perspective, land degradation can adversely affect food security, which in turn affects population well-being, labor productivity, and, henceforth, economic growth and development as well as political stability.

The Global Land Degradation Information System study of land degradation by the Food and Agriculture Organization of the United Nations (FAO) found that 25% of the world's terrestrial surface was highly degraded or degrading, and a further 8% was moderately degraded or degrading (Figure 1). However, on the positive side, 10% was found to be improving (FAO 2010b): these improvements have surely stemmed, at least partially, from investment and education programs based on the principles of sustainable land management.

Sediments carried in rivers from soil erosion affect hydroelectric plants.

Figure 1: Status of Global Land Degradation, 2010



Note: Global area percentages may not add up to 100%, as they are rounded to the nearest percent.
Source: Food and Agriculture Organization of the United Nations. 2010. *The State of the World's Land and Water Resources for Food and Agriculture.* Rome.

Sustainable land management has improved soil in many places but degradation continues, often unnoticed.

Sustainable land management (SLM) has emerged over the last 20 years as the most commonly acceptable current international term and concept, rather than soil conservation, soil and water conservation, land degradation control, or integrated ecosystem management—though each of these is still used in specific situations. This evolution is traced in more detail in Chapter 4, where SLM is described.

Ecosystems and Their Services: Working with Nature

The importance of ecosystem integrity and function has been understood for a long time by ecologists—though this has not been acknowledged (or at least articulated) as an integral part of the struggle against land degradation until recently. Ecosystem services (Box 1) and their importance in maintaining the health of the landscape were highlighted in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005).

The Global Environment Facility (GEF) had introduced its Integrated Ecosystem Management Operational Programme (OP12) in 1999/2000, and its title reflected an integrated and multifocal approach to the management of natural systems. Interestingly, this title and approach strongly resonated in the PRC, where "OP12" (OP-shí'èr) became a byword for the approach underpinned by the PRC-GEF Partnership on Land Degradation in Dryland Ecosystems—until 2014, when it was changed to SLM under the new strategy (PRC-GEF, Ministry of Finance, and State Forestry Administration 2014). However, by 2002, GEF had already merged OP12 into the land degradation focal area (LDFA), and the "positive" thrust of the LDFA became SLM.

The PRC-GEF partnership is a notable example of an initiative to combat land degradation. It emerged through assistance extended by GEF and ADB to the Government of the PRC to help establish the PRC-GEF Partnership on Land Degradation in Dryland Ecosystems. The PRC suffers from large-scale land degradation problems (including soil nutrient losses, deforestation, grassland degradation, and biodiversity loss) that pose a considerable threat to the lives and welfare of its citizens and to the future economic welfare of the country. The primary objectives of the PRC-GEF partnership (which entered its second phase in 2014) are to address land degradation

Box 1: Ecosystem Services

Ecosystem services are the benefits that people obtain from ecosystems, including the following:

Provisioning services. Goods obtained directly from ecosystems (e.g., food, medicine, timber, fiber, biofuel);

Regulating services. Benefits obtained from the regulation of natural processes (e.g., water filtration, waste decomposition, climate regulation, crop pollination, regulation of some human diseases);

Supporting services. Regulation of basic ecological functions and processes that are necessary for all other ecosystem services (e.g., nutrient cycling, photosynthesis, soil formation);

Cultural services. Psychological and emotional benefits gained from human relations with ecosystems (e.g., enriching recreational, aesthetic, and spiritual experiences).

Source: Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: A Framework for Assessment*. Washington, DC: Island Press.

issues, reduce poverty, restore dryland ecosystems, and conserve biodiversity, initially through an integrated ecosystem management (IEM) approach. IEM is a "scientific, ecological approach to natural resources management that aims to ensure productive and healthy ecosystems by integrating social, economic, physical, and biological needs and values" (Radstake et al. 2010). As noted above, the new strategy and second phase use "sustainable land management" as the key term in line with the GEF's LDFA focal area, but SLM encompasses the principles of IEM.

Integrated ecosystem management is a scientific, ecological approach to natural resources management that aims to ensure productive and healthy ecosystems by integrating social, economic, physical, and biological needs and values.

McKenzie and Williams (2015) propose a paradigm where "ecological sustainability constitutes the entry point for all agricultural development," and, if this is embraced, then world food production can become transformed from a driver of environmental change to—paraphrasing their argument—working with nature. Their position supports the need to maintain rich biodiversity within the agricultural system; thus, a strong argument to emphasize agrobiodiversity. This is explored in the following section.

Agrobiodiversity: From Monocrops to Agro-Ecosystems

Agricultural biodiversity, usually shortened to "agrobiodiversity," is a concept that has grown in prominence recently. McNeely and Scherr (2003) provide a concise definition, and this is quoted in the glossary. Agrobiodiversity is recognized in the Convention on Biological Diversity (CBD 1996). Its three main components are (i) the natural biodiversity found above and below ground (as is emphasized in Chapter 2); (ii) the variation among farmed species (plants and animals); and (iii) the complexity of agricultural systems (mixtures of various crops and animals within a farmed unit).

Forests provide clean water, an essential ecosystem service.

Bees play a crucial role in maintaining ecosystem function.

Agrobiodiversity is key to the health of farming systems by providing ecosystem services.

Agrobiodiversity is key to the health of farming systems by providing ecosystem services. It also helps maintain a varied gene pool of plants and animals, and is crucial both as a safeguard against pests and diseases, and for being the primary source of more productive and resilient varieties and breeds. In the context of agrobiodiversity, there is a popular debate between "sharing" and "sparing"—implying the incorporation of wild biodiversity within agriculture versus the intensification of agriculture at the expense of other life forms (*The Economist* 2013a). While it is acknowledged that particular charismatic megafauna and endangered species of plants or animals need to be isolated from farmed areas and protected ("sparing"), it is "sharing" of farmland with nonagricultural species that will bring the sustained ecosystem health that resilient agriculture depends upon.

Agrobiodiversity is vital in maintaining the variety of species grown as well as healthy agro-ecosystems.

Indigenous Knowledge and Innovation: The New from the Old

Indigenous knowledge spans all aspects of land management, including local pesticide concoctions.

One of the most important elements of the "new approach" to conservation, underpinning the evolution of sustainable land management is the acknowledgement of indigenous knowledge and tradition. Farming has been practiced for over 10,000 years, yet for all but the last 200 years or so, the breeding of plants and animals, production systems, pest control, fertility maintenance, soil and water conservation, and irrigation have all been developed by land users themselves. Furthermore, exchange of ideas has been carried out by practitioners, too. Presumably, sharing knowledge at markets and observing other's practices while traveling through the countryside was the progenitor of what we now term "extension systems" (Critchley 2007). The very first books written on farming were by farmers, and before that, skills were simply passed on through the generations verbally—and by learning alongside skilled practitioners.

Critchley et al. (1994) draw four lessons regarding the evolution and survival of indigenous soil and water conservation. First, it has often evolved where moisture limits the production of crops or fruits. Second, it may have been also triggered by the need to cultivate on hillsides with thin soils, where people settled to avoid marauding plain-dwellers. Third, population pressure may simply have obliged people to conserve their soil and water resources more efficiently. Fourth, structural conservation measures (e.g., stone barriers) may, possibly, have led to staking a claim on land—along the lines of "if I build a series of terraces on no-man's land then that plot belongs to me." Naturally, in Asia, perhaps more than in any other continent, landscapes have been visibly transformed by tradition; in this case, by terraces, both rainfed and irrigated. And tradition is not static; innovation carries on at the farm level, though less so now that research and extension services have assumed that role. Nevertheless, farmers are more creative than is generally acknowledged, and can work effectively together with agricultural professionals through pooling their talents and establishing systems of "hybrid knowledge."

Economics of Land Degradation: Cost Not Relevant?

Too often, cost is not considered relevant when soil conservation and land restoration are talked about. Land is viewed as "priceless" and restoration schemes are lauded however much they cost. Particularly prevalent, worldwide, are expensive, nonreplicable, prestige projects, which may appear to advertise good practice but in fact take money and attention away from where it is most urgently needed. There are two closely related issues here. One is opportunity cost. If a limited amount of money is available for soil conservation, where is it best spent? The answer will almost always be in preventing the first stages of erosion on productive land rather than massive ex post rehabilitation schemes—there is a clear analogy here with preventative and curative medicine. The associated argument is to assess the payback or rewards of investing in sustainable land management, a topic which is under investigation through the Economics of Land Degradation (ELD) Initiative (ELD 2013). Payment for ecosystem services (PES) schemes must also feature more strongly: the upstream-downstream debate about the impact of hill farmers on downstream sedimentation is a case in point (see Bruijnzeel and Bremmer 1989; Doolette and Magrath 1990).

The ELD Initiative is "dedicated to raising global awareness of the full economic potential of land and services including market and nonmarket values and the costs of land degradation." The initiative believes that land's economic value is "chronically undervalued, and is commonly determined by immediate agricultural or forestry market values" (ELD 2013). This is a strong starting point. It is a pity that it has taken so long for such an initiative to arise, but two underlying stimuli must be the relatively recent alternative and sometimes competitive demands on land for carbon sequestration and for biofuels.

It is noted also that that monitoring and evaluation (M&E) of sustainable land management and/or land restoration programs has generally been chronically and systematically feeble. Hence, alongside such initiatives as the ELD and the PRC–GEF Partnership, there is an urgent need for M&E systems to be introduced that are *reasonable* (in terms of time and money demands), *reliable* (broadly accurate), and *replicable* (easily translated from one project to another).

Agroforestry: From Farming in the Forest to Forestry in the Farm

Despite the practice being as old as agriculture itself, the term "agroforestry" was first coined in the 1970s and began to be established as a science in the 1980s by the International Centre for Research in Agroforestry (ICRAF)—known as the World Agroforestry Centre since 2002—which was itself set up in 1978. Simply put, agroforestry refers to land-use systems in which trees are grown in association with agricultural crops, pastures, or livestock (Young 1997). A more precise, technical definition by Lundgren (1982) is included in the glossary. It is, as Young (1997) explains, the ecological interactions that are the most distinctive feature of agroforestry. The first efforts were to integrate trees into fields according to scientific patterns, which has a certain irony in that the very long history of farming with trees was characterized by "chaotic mixtures" (see Chapter 5 on homegardens). A second interesting observation is that the origin of traditional agroforestry is to be found in "slash-and-burn" systems ("swidden farming") within forests. These systems were castigated—and commonly still are—though derision has turned to veneration in some quarters when many of these systems were discovered to be sustainable and productive (Cairns 2015).

The overexploitation of natural resources due to the growing population's increased demand for land, trees, and water—coupled with tenure insecurity or the absence of clear property rights—has threatened the sustainable development of agriculture, forestry, and livestock sectors. Otsuka (2001) identified the process by which population pressure leads to the individualization of land rights and its consequences on the management of land and trees, with particular focus placed on the development of agroforestry systems. These agroforestry systems are "becoming important farming systems in agriculturally marginal areas, where people are particularly poor and natural forests have degraded rapidly" (Otsuka 2001).

Borassus sugar palm trees within rice paddies: an example of traditional agroforestry in Cambodia.

Agroforestry is particularly important in the context of this paper in that it forms a central element of each of the four technologies described in Chapter 5.

It is impossible to make decisions about soil—or more broadly, land—without taking into consideration their impact on water.

Water: Land Decisions Are Water Decisions

Initially, soil conservation excluded water from its definition or objective—the two disciplines were differentiated. This was often reflected in separate ministries: the ministry of water on the one hand, and the ministry of environment or forestry on the other. However, it is impossible to make decisions about soil—or more broadly, land—without taking into consideration their impact on water. One of the very earliest changes in many Anglophone countries was from "soil conservation" to "soil and water conservation." However, in some countries where water, rather than soil, is the priority, "water harvesting" has been the focus. Thus, in India, the two seminal volumes Dying Wisdom (Agarwal and Narain 1997) followed by Making Water Everybody's Business (Agarwal et al. 2001) focused on indigenous knowledge and tradition in the field of water harvesting rather than soil conservation—i.e., water harvesting in the sense, principally, of ponding water for deep percolation to replenish groundwater for abstraction by wells for domestic purposes and irrigation. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture (Molden 2007) drew worldwide attention to impending shortages of water for agriculture, and one of the main recommendations was as follows:

> Upgrade rainfed systems—a little water can go a long way. Rainfed agriculture is upgraded by improving soil moisture conservation and, where feasible, providing

> supplemental irrigation. These technologies hold underexploited potential for quickly lifting the greatest number of people out of poverty and for increasing water productivity, especially in Sub-Saharan Africa and parts of Asia.

Water will be an increasingly severe limitation to production in Asia. For example, the PRC, with 20% of the world's population, has only around 7% of global freshwater supplies—yet currently has to produce for this number on just 10% of the global land area (*The Economist* 2013b).

Climate Change, Land, and Carbon: Pool, Sink, and Source

Not only is the soil (and in combination with vegetation, "the land") an extremely important current pool of carbon, it also has the ability to sequester large amounts of carbon from the atmosphere (as a "sink") as well as the potential to emit very considerable quantities through deforestation and soil erosion (as a "source")


Every decision about land affects water.

One of the least well-known facts about climate change is the huge amount of carbon that is held in the soil. This is perhaps because it is unsensational, being less visible than smoke from industry and not as dramatic (or emotive) as tropical forests, and thus unpublicized. Robbins (2011) quotes figures of around 1,550 petagrams of carbon (Pg C) held in the soil compared with about 650 Pg C held in vegetation. Comparatively, the atmospheric carbon pool is about 750 Pg. Not only, then, is the soil (and in combination with vegetation, "the land") an extremely important current pool of carbon, it also has the ability to sequester large amounts of carbon from the atmosphere (as a "sink"). Conversely, it has the potential to emit very considerable quantities through deforestation and soil erosion (as a "source").

According to the Intergovernmental Panel on Climate Change (IPCC 2014c), the agriculture, forestry, and other land use (AFOLU) sector produces just under a quarter of all greenhouse gas emissions. On the positive side, by sequestering carbon through photosynthesis, and storing this within the land, it can be a very significant ally in reducing net carbon emissions, while simultaneously improving organic matter levels in the soil and vegetative cover. As stated by the IPCC (2014c), "a large portion of the mitigation potential in the AFOLU sector is carbon sequestration in soils and vegetation," and conservation agriculture (see Chapter 5) is mentioned as one means. Thus, this is an important co-benefit of sustainable land management (SLM). The antithesis is loss of carbon, through oxidation and formation of carbon dioxide, when vegetation is cut and allowed to decompose, or soil is eroded, and organic matter exposed to the air—even though there is still a debate about how much eroded soil is "captured" in the landscape without (or before) losing its carbon (e.g., Amundson et al. 2015). Nevertheless, soil health and its ability to produce—and to capture more carbon from the atmosphere—are severely reduced by erosion. Undoubtedly, concerns about climate change have given a boost to the profile of SLM for this very reason, and can be further capitalized upon in a positive way to promote better land husbandry.

Forests provide net carbon sequestration benefits in addition to forest products and ecosystem services.

Countries in Asia are highly vulnerable to the adverse impacts of climate change; in fact, more people in Asia are at risk than in any other region of the world. This prompted ADB to address climate change firmly as a contribution to Asia's economic development agenda. ADB's integrated approach to climate change mitigation and adaptation is facilitated by three modalities—financing, knowledge generation, and partnerships—and covers five priority areas for support: (i) expanding the use of clean energy, (ii) encouraging sustainable transport and urban development, (iii) managing land use and forests for carbon sequestration, (iv) promoting climate-resilient development, and (v) strengthening related policies and institutions (ADB 2010a).

As the driver of today's emissions-intensive global economy and the principal source of future emissions, the developing countries of Asia play a critical role in global climate change mitigation. Hence, the governments of the PRC, India, Indonesia, Thailand, and Viet Nam have embarked upon an ambitious policy agenda—i.e., a broad-scale approach involving all sections of the economy, whereby government will be required to achieve the shift to a sustainable, low-emissions development trajectory (Howes and Wyrwoll 2012b).

REDD+: Money Growing on Trees?

The fact that clearing of forests represents a major anthropogenic source of carbon to the atmosphere lends just one more argument to leaving forests intact. Even without this climate

REDD+ can be used to help protect indigenous forests.

change justification, deforestation reduces ecosystem integrity, triggers soil erosion, leads to deterioration of habitats, and thus engenders less biodiverse landscapes, and impinges on the livelihoods of forest-dependent peoples; hence, the initial concept of reducing emissions from deforestation and forest degradation (REDD) in 2005, and then, 5 years later, REDD+. REDD+ translates as "reducing emissions from deforestation and forest degradation in developing countries and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks" (UNEP 2014). The concept is simply a form of payment for ecosystem services: payments are made if existing forests remain intact, are managed, and are improved.

According to UNEP, early indications are very positive, with over $6 billion having been allocated by the global community to finance REDD+ activities (UNEP 2014). But most of the attention currently is on "REDD+ readiness," which precedes actual implementation of the plan. A global REDD+ mechanism is the expected and hoped-for eventual outcome. Once again, as we have seen with sustainable land management, climate change can be used as an extra lever for funds through raising awareness of the need to support a healthy and vibrant landscape.

ADB contributes to the active dialogue on how best to organize knowledge sharing on this new REDD+ scheme to address the major drivers of deforestation in Asia, as well as on how to improve coordination among multilateral and bilateral REDD+ support mechanisms. Countries in Asia, especially those of Southeast Asia, have great potential to benefit from REDD+ because the region's forests and peat lands are not only significant carbon sinks but are also considerable sources of carbon dioxide emissions (ADB 2010b).

Climate-Smart Agriculture: Making Production Climate-Friendly

Agriculture, forestry, and grazing are interlinked, and impacted upon by climate and other environmental pressures. Only integrated approaches based on climate resilient production systems at the broadest scales will make it possible to provide food security while maintaining the ecological resource base. Alongside sustainable land management is its productive relation: climate-smart agriculture. The GEF (2015) has five programs under its land degradation focal area. The second of these is entitled "SLM for Climate-Smart Agriculture," which it views as "an emerging opportunity for increasing the role of SLM." Steenwerth and colleagues (2014) describe climate-smart agriculture as "a set of strategies that can help to meet [climatic] challenges by increasing resilience." Giving more flesh to this description, the FAO set out a fuller definition of climate-smart agriculture as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHG (mitigation), and enhances achievement of national food security and development goals" (FAO 2010a). Climate-smart agriculture embraces the landscape approach as being integral to its effective implementation (FAO 2013b). In 2014, the Global Alliance for Climate–Smart Agriculture was established under FAO, with 75 members initially. Clearly, there is a tightly knit nexus around landscapes, sustainable land management, and climate-smart agriculture: the three are inextricably connected.

Climate-smart agriculture embraces the landscape approach as being integral to its effective implementation.

Climate-smart agriculture addresses production, resilience, and mitigation.

3 The Landscape Approach: Returns and Resilience at Scale

Scientific and development opinion has coalesced around the need to shift away from the management of individual resources to a "landscape approach." Following on from the changing perspectives introduced in Chapter 2, there is a growing international consensus that we need to look at the bigger picture and not just treat sectors selectively and independently. But what exactly does the "landscape approach" mean, why is it necessary, and how does it work in practice?

Landscapes: Integration of Production Systems and Conservation

Landscapes are generally thought of as rural entities—countryside views that can be captured by camera—where they typically comprise farmlands, pastures or rangelands, forests, water courses, wetlands, sometimes mining and other industrial zones, communication and transportation

An Indian landscape—forests, farms, river, roads, houses, and more.

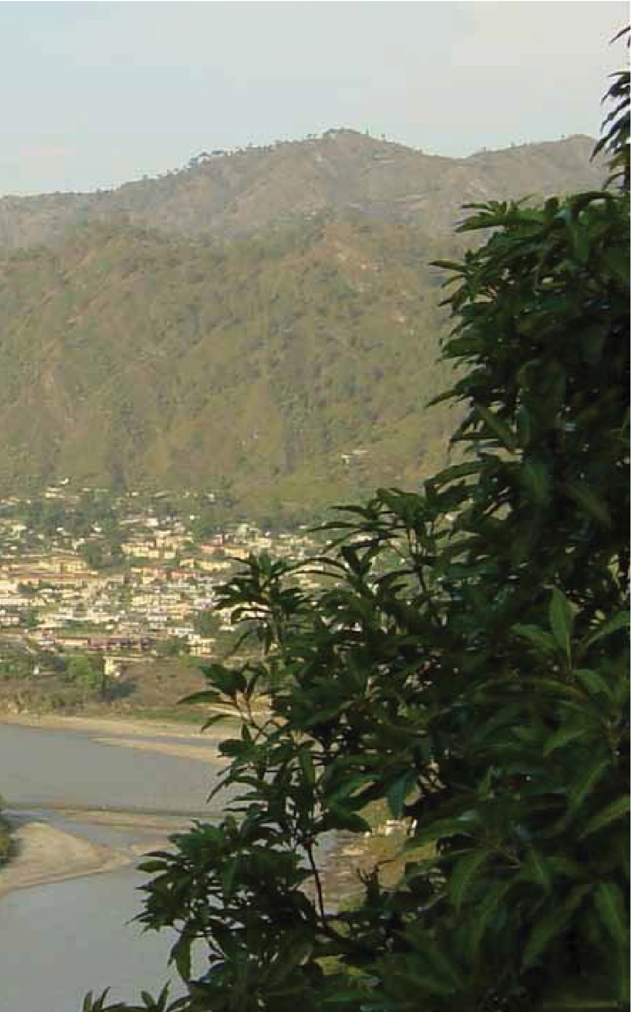
infrastructure, and built-up areas of habitation. There may be, especially in larger landscapes, areas set aside for wildlife—namely, protected areas. However, the term "landscape" can also be applied to urban and semi-urban areas, and even to larger waterbodies and marine zones. "Ridge to reef" is a specific landscape concept that links what happens on the land (e.g., erosion and sediment in rivers) to impacts on marine systems (e.g., damage to the reef). It acknowledges the need for management across that inland–coastal transect. The International Union for Conservation of Nature's initiative, Ridge to Reef (R2R), is an example.

The recently conceptualized and termed "landscape approach" acknowledges and integrates the simultaneous objectives of various production systems with conservation. Thus, the approach is to look at the broad picture, in biophysical and human terms. It is not restrictive or reductionist. Furthermore, it embodies the basics of the integrated ecosystem approach, but recognizes the complexity of land management systems and the need to consider human–environment interactions across sectors and scales. It has evolved to reconcile environmental and development objectives while incorporating climate resilience. But how can it be characterized?

The "landscape approach" acknowledges and integrates the simultaneous objectives of various production systems with conservation. It is not restrictive or reductionist; it embodies the basics of the integrated ecosystem approach.

A recent and comprehensive overview emphasizes sustainable management of mosaic landscapes (Sayer et al. 2013):

> Landscape approaches seek to provide tools and concepts for allocating and managing land to achieve multiple social, economic and environmental objectives in areas where agriculture, hydropower, mining and other productive land uses compete with environmental and biodiversity goals.



An alternative definition in a recent book produced by the International Centre for Research in Agroforestry (now known as the World Agroforestry Centre) introduces the term "functional heterogeneity" and holds that "... thinking at the landscape scale does not simply mean thinking over wider areas...linkages and interactions should exist between landscape units leading to functional heterogeneity..." (Torquebiau 2015). The African Landscapes Action Plan, on the other hand, emphasizes the "neutrality" of natural and/or human-modified ecosystems (Landscapes for People, Food and Nature 2014).

GEF (2015) supports efforts to address land degradation across "rural production landscapes" acknowledging that piecemeal approaches are not enough. A broader brush must be applied to bring degradation under control and restore the integrity of the landscape as a whole.

The closest predecessor approaches and concepts are "watershed development" and

What is the most cost-effective way of protecting the landscape?

"catchment management," but these terms (albeit still useful) have the narrow connotation of fixed hydrological boundaries, and more formulaic approaches to land-use planning based on production enterprises within defined subwatersheds and catchments. "Participatory watershed development" became the term, and approach, of choice, especially in India, in the 1980s and 1990s (e.g., Farrington et al. 1999). This was a major step forward, in that it brought the land users into the planning process and engaged them as "stakeholders"—thus enabling them to express their keen interest in developing their overall resource base. Participatory forest management (see Chapter 5) was a specific subsection of this bold new approach. Integrated ecosystem management would qualify as a closely related approach, though, in this case, conservation is (implicitly) stressed above production, and ecosystems highlighted above the more practical "landscape." Nevertheless, the fundamental principles are shared.

There are three main reasons for the transition from participatory watershed development (and related methodologies) to a landscape approach. First, the landscape approach addresses potential trade-offs between production and conservation. It implicitly (or explicitly) implies that ecosystems must be protected for the services they deliver, and these must not be sacrificed for short-term production gains. Indeed, ecosystem integrity is recognized as the linchpin in sustained landscape health and meeting multiple objectives.

Second is the concept of scale inherent in "landscape thinking." Too often, development and environmental efforts have been criticized for their localized focus: the inability to upscale success (both spatially and temporally) has been a common limitation of otherwise positive initiatives. Raising sights to the landscape level implies an approach that takes cognizance of the need for scaling-up of ventures, while simultaneously avoiding narrow definitions of how big the landscape unit needs to be. At the same time, it needs to recognize a nested (*matryoshka* or "Russian doll") approach, where the different scales that fit within each other build up to an overall landscape.

Third, it aims to reconcile and integrate the different elements of a landscape—the resources and the production systems, as well as the various resource users and their demands on the landscape. Because in reality, everything is linked in an organic whole: the reductionism and isolationism that have conventionally been sought—in terms of, for example conservation areas, forest land, cropping, or mining—does not simply become additive, with a total neatly comprising an ecosystem. The landscape approach seeks to integrate these: it blurs the edges and avoids compartmentalization or building of "silos," as modern development jargon terms it.

The GEF's Scientific and Technical Advisory Panel has recently stressed the need for transformation in socio-ecological development, and the landscape approach fits perfectly within their definition. "Transformation is a process of moving to a socio-ecological system with different identity, structure, and functions to achieve desired sustainability goals. Often transformation is needed at one scale to maintain the resilience (or system identity) at another scale" (O'Connell et al. 2015).

A landscape approach needs adequate time to develop and demonstrate its impact.

Sayer et al. (2013) list the following 10 Principles for a Landscape Approach in their paper of the same title:

1. Continual learning and adaptive management: *landscape processes are dynamic*;
2. Common concern entry point: *shared negotiations based on trust*;
3. Multiple scales: *outcomes at one scale are influenced by outcomes at other scales*;
4. Multifunctionality: *landscapes have multiple uses and purposes*;
5. Multiple stakeholders: *engagement of all stakeholders required*;
6. Negotiated and transparent change logic: *transparency is basis of trust*;
7. Clarification of rights and responsibilities: *rules needed to assist conflict resolution*;
8. Participatory and user-friendly monitoring: *information from various sources*;
9. Resilience: *active recognition of threats and vulnerabilities*; and
10. Strengthened stakeholder capacity: *learning processes of the landscape approach*.

Development Consideration: Time and Scale Perspectives

It is crucial to acknowledge another fundamental principle that could and should be added to the list—that of sustained and long-term involvement. A landscape approach needs adequate time to develop and demonstrate its impact. The implication is clear: landscape interventions should always take duration into account. They do not lend themselves to typical 3- or 4-year project cycles.

As noted, it is important not to oversimplify: landscape approaches are complex and location-specific. Indeed, the Center for International Forestry Research goes as far as lauding vague descriptions, and praising the fact that the landscape approach defies simple definition

Land users are familiar with interactions within a landscape. The map describes different land uses and water flows as recognized by the farmer.

(Sunderland 2014). In addition to the variations in capital, capacity, and enforcement among regions of the world, ecosystems among and within those regions vary in terms of biophysical conditions such as climate, water, and soils. Issues of tenure rights and access to land obviously determine land management practicalities.

There are developing issues, inevitably, that still need to be resolved under the landscape approach: one of these complexities is the aerial scale that is taken to constitute a "landscape." FAO (2013b) noted that, in a landscape approach, "the management of production systems and natural resources covers an area large enough to produce vital ecosystem services, but small enough to be managed by the people using the land which is producing those services." Though the general assumption seems to be that the approach is freed from precise definition in terms of scale, there are nevertheless important hydrological and social issues at stake (see Chapter 2). Size does matter. As the size of the landscape increases, upstream–downstream interactions—in other words, the impact of upstream activities (cultivation, afforestation, etc.) on downstream systems (irrigation, water for livestock, and environmental requirements)—carry more weight. Larger landscapes also become more heterogeneous, biophysically and socially too. Is it still a unit which, to the stakeholders involved, is "meaningful, manageable, and measurable"? Sensitivities to who "owns the rights to what" are paramount over the landscape as a whole. A particularly important issue concerns common property, and community management of grazing and forest resources. Finally, there are implications in terms of administrative zones.

Landscape approaches must therefore be tailored to specific regions, biomes, cropping and livestock systems, and socioeconomic contexts. Approaches that seek to reduce short-term food outputs at the expense of environmental gains require integration of knowledge from multiple disciplines: agronomic, biological, social, economic, and political. Achieving the full potential of landscape approaches will require the development of policies and enabling environments that allow and stimulate action; but before that, workable and understandable methodologies must be developed and clearly articulated. Key to long-term and broad impact and acceptance, naturally, will be capacity building—and much of that capacity will grow through hands-on experience, in the landscapes themselves.

Livestock are an important component of landscapes.

Sustainable Agriculture: Working with Ecosystems

Landscapes dominated by agriculture in developing countries are prime candidates for the new approach. Here, the tools for managing the landscape—those that fall under climate-smart agriculture—are known and already familiar to practitioners. But farm production comes with a raft of other benefits. Harvey et al. (2014) put it succinctly:

> Many of the activities needed for adaptation and mitigation in tropical agricultural landscapes are the same needed for sustainable agriculture more generally, but thinking at the landscape scale opens a new dimension for achieving synergies… intentional integration of adaptation and mitigation activities in agricultural landscapes offers significant benefits that go beyond the scope of climate change to food security, biodiversity conservation and poverty alleviation…

In developing nations, sustainably increased productivity can readily stem from systems that are not capital- and input-intensive, but work with, and are supported by, ecosystems—this is the paradigm championed by McKenzie and Williams (2015). Practices such as conservation agriculture, as well as mixed and relay cropping, agroforestry, and others, are important means of supporting sustainable food production. Each of these incorporates agrobiodiversity in its agro-ecological interpretation. These interventions can be upscaled to the landscape so that they influence and benefit from the scale at which water and nutrient cycling and energy fluxes take place.

Unsurprisingly, moving forward through a landscape approach has been recognized and supported by a growing number of institutions, including explicitly (or implicitly through espousing climate-smart agriculture) the Center for International Forestry Research, FAO, GEF, International Fund for Agricultural Development, International Union for Conservation of Nature, and the World

Bank, as well as ADB. It is embedded in the Convention on Biological Diversity and is integral to the Millennium Ecosystem Assessment and the United Nations Sustainable Development Goals. Significantly, the Global Commission on the Economy and Climate has recently endorsed a landscape-based approach toward better land use.

In conclusion, the landscape approach builds on ecosystem services for multiple development and conservation goals. Thus, through valuation of ecosystem services vital for production, it supports the integration of natural capital considerations in economic sectors toward the achievement of a green economy and green development.

Designing Lasting Solutions: Sustainable Land Management

4

If the landscape approach sets the overall framework, then sustainable land management (SLM) provides many of the most powerful tools for action. SLM ensures the health of the land—in its widest sense, of soil, fauna and flora—by maintaining and improving its ecosystem function. SLM, in the framework of landscape management, is the way forward to achieve multiple co-benefits at scale.

Sustainable land management ensures the health of the land by maintaining and improving its ecosystem function.

Land Management: Evolving Approaches

The beginning of the 1980s saw a new approach developing to what previously had been always considered an agricultural engineering discipline. The conventional approach was to control land degradation by "soil conservation," comprising physical barriers designed and constructed by engineers, to stop soil in its tracks as it moves downslope. But then the concepts of land users' involvement in planning ("participation"), gender sensitivity, the connection of conservation and production ("land husbandry"), the importance of water conservation for crops, and respect for local traditions and indigenous knowledge all came together and profoundly changed attitudes among development professionals.

Lundgren and Taylor (1993), documenting the experience of the Swedish International Development Cooperation Agency in East Africa, entitled their booklet *From Soil Conservation to Land Husbandry*; and Hudson's 1992 follow-up to his 1971/1981 classic, *Soil Conservation*, was entitled *Land Husbandry*. Chinene et al. (1996) helpfully tabulated *then* and *now*, comparing (for example) *blanket recommendations* versus *a cafeteria of choices*; and *professionals holding the stick* versus *listening and learning*. Perhaps the most compelling compilation of the new approach was distilled by Hurni (1996) in the publication *Precious Earth: from Soil and Water Conservation to Sustainable Land Management*, prepared for the International Soil Conservation Organization conference of the same year in Bonn.

Sustainable land management, in addition to countering land degradation and erosion, provides crucial support to biodiversity and ecosystems. It is a cornerstone in building climate change resilience across all scales, for storing carbon in the land, and in improving production and long-term food security.

From that date onward, the control of land degradation was approached, at least in theory, by SLM, with all the elements that constituted this new, more sensitive and rounded approach. It should be added, however, that the terminology was (and has been) more strongly associated with Africa than Asia, where (in English) there has been more familiarity with the umbrella term "watershed management."

Relevant at both the local and landscape levels, SLM, in addition to countering land degradation and erosion, in particular, provides crucial support to biodiversity and ecosystems. It is, furthermore, a cornerstone in building climate change resilience across all scales, as well as for storing carbon in the land. Perhaps above all, it is key in improving production and, thus, long-term food security (e.g., Branca et al. 2013; Henry and Murphy 2014).

SLM can be defined as

- "a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management to meet rising food and fiber requirements while sustaining ecosystem services and livelihoods" (World Bank 2006); or alternatively as,
- "the use of land resources, including soil, water, animals and plants for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and ensuring their environmental functions" (WOCAT 2007).

Assessing Technologies: The TEES-Test

SLM technologies, supported by appropriate approaches (WOCAT 2007), should obviously be subject to assessment for suitability in specific situations. It is suggested that this can be achieved by applying the "TEES-test" (Critchley 2007). The "TEES-test" comprises four criteria against which a technology is measured—namely: technical effectiveness, economic validity, environmental friendliness, and social acceptability (Box 2).

Box 2: The TEES-Test

The TEES-test acts as a preliminary filter for assessing technology in terms of the following four criteria: technical performance, economic returns, environmental friendliness, and social acceptability.

Technical effectiveness: Does it work well? Is its performance (e.g., in terms of erosion control, etc.) as good as, or better than, current alternatives?

Economic validity: Do the benefits outweigh the costs? Is it affordable to the target group when these may be the poorest in society (etc.)?

Environmental friendliness: Are there any negative environmental impacts? Is off-site pollution or extra erosion caused (etc.)?

Social acceptability: Is it antisocial by creating problems for others? Has it potential to spread? Does it benefit women and youth equally (etc.)?

Appropriate indicators need to be established for each of these criteria and weights also applied; these will inevitably differ from situation to situation. Nevertheless, the principles of performance and sustainability are inherent in the TEES-test.

Source: W. Critchley. 2007. *Working with Farmer Innovators: A Practical Guide*. Centre for International Cooperation. Free University Amsterdam.

For the Global Environment Facility (GEF), SLM comprises the key set of actions to counter land degradation or desertification under the land degradation focal area (LDFA), which was established in 2002. The GEF's recent primer on finance under the LDFA (and multiple focal areas with a joint agenda) is even entitled *Sustainable Land Management Financing in the GEF*, and it is significant that the discussion in that document centers on the advantages of SLM rather than the more negative connotation of land degradation or desertification (GEF 2015). For GEF, SLM is vitally connected to achieving global environmental benefits (see glossary) and also attaining food security (Henry and Murphy 2014). Furthermore, as one of its program priorities (Objective 3, Program 4), GEF sees the landscape approach as a means of scaling-up SLM (GEF 2015).

SLM plays an active role in rural landscape approaches and embraces all scales. It is essentially a tool under the landscape approach, and can be put to work, as we shall see in Chapter 5, from household to forest. And as noted earlier, climate-smart agriculture can be considered as the engine for the productive side of SLM.

Climate-smart agriculture can be considered as the engine for the productive side of sustainable land management.

As noted in Chapter 2, it is ironic that climate change concerns have given a boost to SLM. That is because of the recognition that SLM helps at least maintain, and should usually increase, carbon in the soil and vegetation—in the soil, through an increase in carbon-rich organic matter; and in vegetation, through improved plant performance. The latter is achieved through increased photosynthesis and buildup of carbon in both woody and nonwoody vegetation. Thus, the more effective the system of SLM, the more carbon is taken from the atmosphere and sequestered in the land. This, in turn, improves resilience of systems against drought and other climatic shocks.

When practiced on farmland, then, it could be argued that this is where “SLM meets climate-smart agriculture;” on forest land, it could be said that here “SLM meets REDD+.” Landscape approaches acknowledge and embrace all of these.

5 Technologies for Managing the Landscape: From Hilltop to Homestead

Sustainable land management provides a basket of options for managers of productive landscapes. Four have been chosen here for focus: (i) participatory forest management, (ii) cross-slope barriers, (iii) conservation agriculture, and (iv) homegardens. The choice is based on various factors, but primarily to demonstrate the span of systems. According to the World Overview of Conservation Approaches and Technologies (WOCAT) categorization, we have one example broadly representing each category: management (participatory forest management), structural (cross-slope barriers), agronomic (conservation agriculture), and vegetative (homegardens). The systems range from those found at the top of the catchment to the bottom. There is a mix of extensive and intensive. Two are quite new, at least conceptually (participatory forest management and conservation agriculture); two are venerable in their heritage (cross-slope barriers and homegardens). All, however, present the ability to achieve impact with multiple benefits—i.e., conservation, food production, improved livelihoods, biodiversity, and climate change resilience and mitigation. Furthermore, each has significant potential for scaling-up: even if improvements can be made, this should not be a barrier to wider dissemination.

The landscape approach is firmly embedded in resource tenure and in community-based natural resource management.

Participatory Forest Management: Handing Back the Jungle to the People

A typical Asian landscape below the highest altitudes is encircled by forest, and forests are crucial elements in the provision of ecosystem services. Deforestation leads to soil erosion, loss of carbon, and the disturbance of ecosystems. Livelihoods suffer, of both those dependent on the forests and people living downstream. Legislation by governments to protect forest often has the perverse effect of encouraging local communities to illegally exploit those resources. Thus, a cornerstone of improving forest management has been the transfer of rights and responsibilities back to the local people themselves. The landscape approach, in this context, is firmly embedded in resource tenure and in community-based natural resource management.

Joint forest management, often called participatory forest management elsewhere, took off in India during the mid-1980s, having been pioneered there a decade earlier. Up to that time (mid-1980s), according to a 2002 study published in WOCAT (2007), less than half of the official forest land had good cover—being held under government ownership and poorly protected, it was subject to degradation by villagers helping themselves liberally to timber, fodder, and even topsoil. Community initiatives, encouraged by nongovernment organizations (NGOs), were the spur for action. The national Joint Forest Management Resolution of 1990 supported the rights of communities to take control of forests close to their villages. The communities received technical support and incentives, such as the construction of dams for irrigation, from NGOs working in tandem with the government. In return, the communities established "social fencing" (joint agreements not to trespass with livestock or for illicit purposes into the forest); and, while maintaining the forest and improving it through enrichment planting with desirable woody species, they established rules for sustainable harvest of non-timber forest products (WOCAT 2007). In many ways, this was a reversion of ownership and management to the original pre-government system.

Government forests were plundered for products—here women are harvesting leaves for fodder in the twilight.

There was initial success and the predictions of widespread adoption across India were realized. It was scaled up across the country and at its peak, there were over 100,000 communities managing 22 million hectares of forest and it was supported by a multitude of donors (Baheranwala 2011). However, Baheranwala's 2011 follow-up study of the program a decade after that originally investigated under WOCAT (WOCAT 2007) showed that not all was well. While there were many accomplishments of joint forest management (JFM) including restored vegetation and reduced erosion, as well as better relationships between communities and the government's forest department, JFM had lost much of its innovativeness and was reverting to a top-down program. The well-intentioned but flawed Forest Rights Act of 2006 caused conflicts across the nation and led to the halting of JFM activities. Baheranwala (2011) described the overall JFM program as "being at a crossroads."

Joint forest management brings together the community, nongovernment organizations, and government specialists.

Through joint forest management, a recovered forest in India with a reservoir for irrigation now well protected.

Secure tenure rights (by local communities) are necessary to protect local populations and to increase resilience to threats from both climate change and mitigation efforts.

Taking up the topic of forest tenure more broadly, Larson et al. (2010) report that this type of forest reform had led to at least 200 million hectares of forest having been transferred to communities and indigenous peoples across Asia, Africa, and Latin America. The overall experience is adjudged to be positive, but the picture is mixed:

> The granting of rights has sometimes transferred limited new rights or taken away others and has often been laden with responsibilities to conserve forests, but it has also offered new livelihood opportunities and/or improved forest conditions in many cases.

Perhaps of most current significance is the advent of REDD+ (formerly REDD) under climate change agreements. In the view of the authors, secure tenure rights (by local communities) are necessary to protect local populations and to increase resilience to threats from both climate change and mitigation efforts. In this context, they hold that such rights are needed for communities to benefit from REDD (Larson et al. 2010).

The REDD/REDD+ program has injected fresh impetus into forest rights, responsibilities, and reform. Under the REDD+ scheme, "forest managers are compensated by developed countries and businesses for the global benefits derived when forests reduce atmospheric concentrations of carbon dioxide that lead to global warming" (ADB 2010b).

The United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation (or UN-REDD Programme) convened a global symposium in 2013, and organized an international working group on the topic. The ensuing publication (UNEP 2014) informs us that:

> If designed well, REDD+ can thereby contribute to the key elements of a Green Economy: low carbon development, social inclusiveness, increased human well-being, and respect for natural capital. It can then directly serve the interests of the millions of people in developing countries who directly depend on the forests for survival.

The document concludes by stressing that the issue of forest tenure is central to the successful implementation of REDD+, and that safeguards are essential to ensure that forest dwellers are empowered to participate in decision making and "earn their fair share of benefits." They can also be involved in collecting data to assess carbon stocks in the forest. REDD+ has advanced efforts to address issues on forest conservation and supporting truly sustainable forest management practices (ADB 2010b). While only pilot projects under REDD+ are currently under way, it is clear that a fully developed internationally ratified REDD+ program should give a new stimulus to participatory forest management and, in the context of this current paper, it is particularly pertinent that the document states that REDD+ can be best approached "at a landscape scale."

A series of chapters in Cairn's recent book (Cairns 2015) approach the topic of participatory forest management from the angle of ancient systems of shifting cultivation (or swidden) and forest maintenance and manipulation. Many of these forest-based production forms are now diminishing in importance and evolving into more conventional agricultural systems. Nevertheless, much swidden agriculture is still practiced and, in some quarters, continues to be maligned as a destructive "slash and burn" activity. Yet, ironically, swidden farming can alternatively be viewed as the origin of agriculture, the inspiration for homegardens, and the ancient ancestor of the science now termed "agroforestry."

Swidden agriculture is still practiced and, in some quarters, continues to be maligned as a destructive "slash and burn" activity. Yet, swidden farming can alternatively be viewed as the origin of agriculture, the inspiration for homegardens, and the ancient ancestor of the science now termed "agroforestry."

Cairns' book also deals with the potential of REDD+ for a new wave of participatory forest management in various chapters (e.g., Dove; Raintree and Warner; Alcorn and Royo; Bayrak, Nam Tu, and Burgers: all in Cairns 2015). There is a consensus that whatever activities eventually ensue under a full REDD+ program—whenever that might be and in whatever form—at least attention is being given to issues of tropical forest management, rights to resources, indigenous peoples, and the spread of benefits, whether global environmental benefits, local ecosystem services, or financial compensation. Raintree and Warner (2015), drawing on Pearce (2012), sum this up:

> Even if REDD+ is not formally agreed upon and implemented, the current attention to people, forests and trees has opened the door to a reconsideration of the importance of trees on the landscape, the role of local people in forest management, and indigenous peoples' and rural communities' rights to access and co-benefits.

The term "cross-slope barriers" basically describes any structure made from stone, earth, or wood that acts as a barrier to runoff and sediment. These barriers are laid out on the contour line, though they may be deliberately formed on a slight gradient to allow safe drainage of excess runoff in more humid areas. The best known of these barriers are terraces.

Cross-Slope Barriers: Contour Belts

The term "cross-slope barriers" basically describes any structure made from stone, earth, or wood—or composed of living vegetation—that acts as a barrier to runoff and sediment. Often these barriers are laid out on the contour line (either by trained eye, or using surveying equipment), though they may be deliberately formed on a slight gradient to allow safe drainage of excess runoff in more humid areas. The best known of these barriers are terraces, though growing ever more popular are vegetative options, which are cheaper to establish and are basically self-maintaining.

Bench terraces provide for better management of soil and water on cultivated hillsides. Additionally, they facilitate farm operations by hand or machine (Bridges et al. 2001). Though popularly associated with irrigated agriculture, terraces are commonly found under rainfed conditions—and there are worldwide examples of traditional structures dating back thousands of years. The World Heritage Site of Machu Picchu in Peru features the ancient Inca terraces, which represent a window on ancient agriculture; and, in the PRC, there is a history of rainfed terracing in the Yellow River Basin that is 2,000 years old (Critchley 2009). The Banaue irrigated rice terraces of Ifugao in the Philippines were also constructed thousands of years ago, and currently, while still in productive use, have become one of the few examples of "agro-ecotourism" with a stream of local and foreign visitors coming to marvel at the steepness and intricacy of the structures (Critchley et al. 2001; WOCAT 2007).

The ancient Banaue Rice Terraces in the Philippines have become a site of agro-ecotourism.

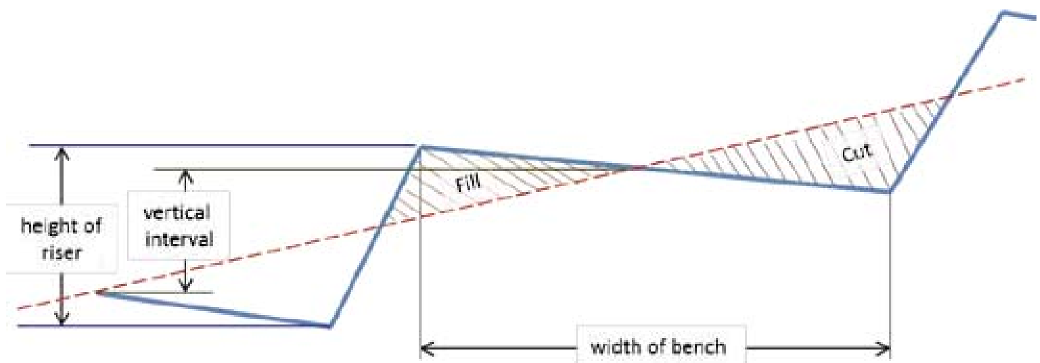
Traditional stone-faced bench terraces for rainfed crop production are a common site in India's Himalayan foothills.

Terraces are a clear example of a conservation technology evolving independently on different continents. Their ubiquitous occurrence dispels the myth that sustainable land management practices always have to be taught from outside: many (though not all) of the best practices have been devised by innovative farmers throughout the world, and built without technical support or financial incentives. While bench terrace construction was a common feature of conservation programs last century, with the exception of massive programs in the PRC (see WOCAT 2007; PRC-GEF and LADA 2008; and World Bank 2010 for an extraordinary achievement on the Loess plateau), the current emphasis has turned toward low-cost contour vegetative barriers. Thus, terrace construction on steep slopes is being increasingly consigned to history and ecotourism because of costs and, in some places, increasingly stringent legislation regarding cultivation of unstable steep slopes.

The best known and most widespread form of terraces in Asia are bench terraces. These can be defined as terraces having a bed (the planting area) with a gradient of 3 degrees or less in any direction (otherwise, they are better described as "forward-sloping" or "back-sloping" terraces), and a bed width of usually 10 meters or less (Critchley et al. 2001). They are generally continuous down a hillside, with the top of a given terrace riser elevated slightly above the bed of the terrace upslope. The terrace riser, or terrace wall, may be made of stone (almost invariably so, where loose stone is available), or earth. Earth risers are often protected by grass, especially fodder grass, which can be cut for stall-fed cattle or goats, thus making productive use of the banks (risers) separating cropping strips. Conversely, unprotected earth risers, being steep and exposed, can constitute a significant source of sediment flowing out of the landscape themselves (Critchley et al. 2001).

Level (flat-bed) bench terraces are employed to hold rainfall where it falls (in situ), whereas laterally graded terraces, with a backslope toward the riser, allow for discharge of excess runoff in humid areas (Critchley 2009). Bench terraces can be constructed by excavation and redistribution of topsoil (Figure 2) or, more commonly, encouraged to develop naturally over time behind stone bunds, through the movement of soil downslope as a result of tillage and water erosion.

Figure 2: Cross-Sectional View of Bench Terraces



Source: N. W. Hudson. 1971 and 1981 second edition. The Design of Bench Terraces. *Soil Conservation*. London: B.T. Batsford Limited.

Vegetative barriers, and especially those composed of grasses and associated vegetation, have long been an important form of soil and water conservation.

Terraces are suitable on hillsides with deep soils and high productive potential. However, bench terraces are inappropriate for the very steep slopes (often well above legal limits of cultivation) that have been brought into cultivation as populations expand into mountainous areas (Critchley 2009). Above slopes of 25–30 degrees, construction costs become prohibitive because the area of terrace bed gained is very little compared with the work involved in developing high and closely spaced risers —and the increased risk of mass wasting through landslides. It is not only the cost of construction that can be a constraint in bench terraces, but the essential and regular maintenance of terraces is time-consuming and expensive as well (Critchley 2009). Globally, there are examples of ancient systems slipping, literally, into disrepair; and without outside investment, collapsing terrace walls lead to worse land degradation than comparable untreated slopes.

As well as reducing erosion, well-maintained bench terraces allow cultivation by hand, animal draft, or even machine where the original steep slopes would be difficult or impossible to crop otherwise. However, bench terraces are not a panacea; for all their merits, they are "uncertain steps" on tropical hillsides (Critchley et al. 2001).

Vegetative barriers, and especially those composed of grasses and associated vegetation, have long been an important form of soil and water conservation. Such strips are generally formed along the contour, perpendicular to the flow of runoff and sediment. They form living barriers and, thus, can be cheap to establish and maintain. While vegetative strips (ranging in width from 30 centimeters to over 1 meter) allow some throughflow of excess rainfall runoff, while simultaneously holding back most sediment, land leveling occurs between the barriers over time. Sediment backs up behind the vegetation, which grows stronger (stimulated by the richness of the eroded particles) and gradually benches form.

Irrigated terraces for rice production have been used for thousands of years in the People's Republic of China.

As with grasses protecting terrace risers, vegetative barriers can provide secondary benefits of fodder for livestock or mulching for fruits and vegetables when the vegetation is trimmed. Many species can be used as barriers: contour hedgerows of leguminous trees (e.g., *Gliricidium sepium*) are used in some locations, while sugarcane is also employed as a dual-purpose, directly productive, hedgerow (Critchley 2009). It must not be forgotten that dense hedges surrounding fields may also act as de facto barriers to erosion. An overview of vegetative barriers is given by Barker et al. (2004).

WOCAT (2007) documents and gives specifications for two very different examples: (i) natural vegetative strips in the Philippines, where vegetation is left to grow on an unplowed contour strip; and (ii) vetiver grass lines in a sugarcane estate in South Africa.

Natural vegetative strips emerged from farmers' unwillingness to invest much in conservation—despite the fact that a very effective integrated package entitled Sloping Agricultural Land Technology (SALT) had been developed for the area. SALT was based on contour hedgerows of multipurpose leguminous tree species such as *Calliandra tetragona*, *Leucaena diversifolia*, or *Gliricidium sepium* (see, for example, Palmer and Laquihon 2004 for a description of SALT and associated hedgerows). Development specialists had little choice but to accept that a "second best" compromise option may be the best way forward. Natural vegetative strips, which are about 0.5 meters in width, are laid out along the contour. The spacing between strips is determined based on a vertical interval of 2–4 meters (vertical interval being the height differential between strips). Vegetation is allowed to grow naturally, though there is the potential for enrichment planting of fruit or fodder species within the strips (Garrity et al. 2004).

Vetiver grass (*Vetiveria zizanioides*) was vigorously promoted by the World Bank and others (see Grimshaw and Helfer 1995) as an effective barrier against erosion—and the WOCAT case from South Africa shows where it can be appropriate. However, vetiver has seldom been well accepted by small-scale farmers, the reason being that they prefer vegetation that can be fed to livestock, such as napier grass (*Pennisetum purpureum*). While Garrity et al. (2004) were

Contour grass strips of fodder species (e.g., napier grass) control erosion and provide fodder for cattle.

advocating natural vegetative strips, they noted that vetiver "has very little use as a ruminant fodder." Hellin (1999) was more outspoken, characterizing vetiver as "a classic example of a technology that addresses problems identified by outsiders."

In terms of applicability, vegetative barriers are widely appropriate across both small-scale and large-scale systems. Many species can be used, and combinations of plants are also possible—e.g., indigenous species can be mixed with high-value fruits. Fodder grasses are an alternative, as has been noted.

Apart from the indirect benefits of vegetative barriers—including fodder, mulch, fruits, and (in some cases) improved biodiversity—the main objective is to control erosion, and maintain most rainfall in situ (Critchley 2009). Critchley et al. (2004) reviewed six sets of experimental results from the tropics, worldwide. Two recorded no significant difference between the hedgerow and the control, but the other four demonstrated remarkable effectiveness. Of these four, one was a set of 14 treatments reported by Young (1997) which produced, on average, a reduction in erosion from 96 tons per hectare (t/ha) (control) to 14 t/ha (treatment).

Sustainable land management has increasingly taken the position of emphasizing good husbandry in-field. Not only do these measures lessen erosion directly by covering the surface and building up organic matter in the soil...there are also direct benefits to farmers through improved and more stable production.

It is a sign of the times that a general trend over the last 25 years has been to move away from structural solutions to soil and water conservation, and concentrate on the area "between the barriers." In other words, sustainable land management has increasingly taken the position of emphasizing good husbandry in-field: mulching, no-till, rotation, intercropping, agroforestry, manuring, and so forth. Not only do these measures lessen erosion directly by covering the surface and building up organic matter in the soil (which reduces its erodibility), but there are also direct benefits to farmers through improved and more stable production. It is also important to note that, in many areas, this transfers much of the responsibility from men (barrier builders) to women (crop cultivators).

Significantly, cross-slope barriers, once the mainstay of soil conservation, have become thought of now as support structures or a framework rather than the chief defense against soil erosion. Soil and water conservation engineers, in turn, are being replaced by sustainable land management specialists, whose remit is broader and much more closely linked to the land, to ecosystems, to resilience, to productivity, and to the people who work on that land.

Conservation Agriculture: Three Pillars of Soil Health

The emergence of "conservation agriculture" has been one of the most significant success stories in modern rainfed agriculture (see Goddard et al. 2007). Though no-till farming was introduced tentatively during the 1970s on large-scale farms in Europe, the United States (US), and elsewhere, it was only with the emergence of new less-toxic nonselective herbicides and specialized machinery (seed drills and straw-chopping combine harvesters, etc.) that CA took off rapidly in the late 1980s (Critchley 2009).

Plowing—the standard land preparation treatment worldwide for millennia, used primarily to control weeds—is detrimental to the soil, because of the disturbance it causes to micro-organisms, organic matter, and soil structure (Critchley 2009). The development of relatively safe herbicides and specialized straw-chopping and direct-drilling machinery renders plowing unnecessary. Soil health improves under CA, and waterbodies are less polluted and incidences of eutrophication reduced, because fewer agrochemicals are carried off in runoff together with eroded sediment. Furthermore, greenhouse gas emissions are lessened by maintaining the organic carbon stock in the soil and economizing on fossil fuel consumption in farm operations. While crop yields are not necessarily increased immediately, the costs of production are reduced and, in the case of large-scale arable enterprises, the speed with which land can be planted within a limited "window" of time can be extremely important (Critchley 2009).

Soil structure and health improve under conservation agriculture.

Based on the three principles of no- (or minimal) tillage, maintaining a surface cover, and crop rotation, CA reduces the energy (and carbon emissions) involved in, and costs associated with, preparing land. It also maintains good soil structure and underground biodiversity, reduces surface erosion, and increases soil moisture in dry zones (Critchley 2009). Derpsch and Friederich (2009) enthusiastically hail the successes and further potential of CA as follows:

> No-tillage/Conservation Agriculture has developed to a technically viable, sustainable and economic alternative to current crop production practices. While current crop production systems have resulted in soil degradation and, in extreme cases, desertification, the adoption of the no-tillage technology has led to a reversion of this process. Soil erosion has come to a halt, organic matter content, soil biological processes and soil fertility have been enhanced, soil moisture has been better conserved and yields have increased with time.

The Food and Agriculture Organization (FAO) has established the Community of Practice and the Framework for Action, which emerged from a landmark conference in 2008 (visit FAO's Conservation Agriculture site at www.fao.org/ag/ca). Conservation agriculture has quadrupled from the turn of the century to 2015, and currently occupies 157 million hectares (equivalent to 3% of the world's cropped land). The largest areas under CA are in the US, Brazil, Argentina, Canada, and Australia, which between them account for nearly 85% of the global total (FAO AQUASTAT 2015). The rapid uptake among relatively small-scale farmers in South America, especially Brazil, is one of the most noteworthy recent developments in world farming.

In Africa, progress is slower. This is due to several factors, including entrenched traditions of cultivation, unavailability or affordability of appropriate machinery, and poor markets for produce. However, the country that is making the most progress with CA among small-scale farmers, namely Zambia, is pioneering the use of the indigenous leguminous tree *Faidherbia albida* within a CA-based agroforestry system. The tree improves soil fertility significantly and is well accepted by farmers.

A recent World Bank publication features African farmers from an unnamed country visiting the PRC and exchanging experiences in CA. It is presented in a cartoon strip format and highlights how much room there is for mutual benefits in cross-country experience: the incorporation of agroforestry trees is a message from Africa, while use of appropriate machinery is a lesson from the PRC (Li et al. 2014).

Despite lagging behind in terms of area, the increase in area under CA in Asia is also significant in recent years. The PRC's area under CA has expanded to 6.7 million hectares in 2014 from an insignificant amount in 2000 (see Box 3); Kazakhstan now has some 2.0 million hectares; and India, in third place within Asia, has some 1.5 million hectares being cropped under conservation agriculture (FAO AQUASTAT, 2015). This is evidence of a trend being set, though there are various hurdles to be overcome, as outlined in an analysis of CA in India (Bhan and Behera 2014) in which lack of appropriate machinery, competition for crop residues, insufficient knowledge amongst farmers, and entrenched attitudes are highlighted as constraints. However, these are challenges that can be overcome, and it will be no surprise if the exponential increase continues in Asia, particularly in the PRC, where it is underpinned by considerable subsidies.

Conservation agriculture in the People's Republic of China is being widely promoted.

Box 3: Upscaling Conservation Agriculture in Shaanxi Province, People's Republic of China

Linwei in Shaanxi Province is an area where conservation agriculture (CA) has taken off strongly in recent years. CA has been promoted through the Department of Machinery of the Ministry of Agriculture, who initially carried out demonstrations for 2 years on farmers' fields. Based on the findings, farmers are now offered a 30% subsidy on purchase of CA-adapted machinery. This approach, together with benefits realized to the farmers, has explained the very rapid uptake, which continues today: there are over 3,000 hectares under CA in the locality, and this area is growing rapidly.

The initial impetus for the introduction of CA around 1999 was to end the practice of burning stubble and straw, which was a serious hazard in terms of air pollution. The production system is based on continuous irrigated cropping of wheat followed by maize—two crops in a single year. However, there is no rotation with a legume or other noncereal crop. Large fields are subdivided in terms of ownership. Benefits include yields of 9,000 kilograms per hectare (kg/ha) of wheat and around 12,000 kg/ha of maize, as well as a reduction in the amount of water required for irrigation of two-thirds. Apparently, soil organic matter has increased over a 10-year period from 1.15% to 2.46%.

Close by, the North-West University of Agriculture, Forestry, Science and Technology at Yangling has a mechanization college where innovative CA machines—straw choppers, direct drills—of various sizes are under development. Around 20 models have already been patented and are in commercial production.).

Source: W. Critchley. 2014. Internal report for the Asian Development Bank's policy and advisory technical assistance on *Integrated Strategy for Sustainable Land Management in Dryland Ecosystems* (TA 8162-PRC). Manila.

The transition to CA means investment in new, specialized machinery. The plow is dispensed with. After harvest, the soil may be loosened and straw chopped and incorporated. Then spraying with a nonselective herbicide kills the weeds and volunteer plants that emerge. A cultivator drill follows: the surface soil is lightly disturbed (though not inverted) and seed drilled into this bed. The seedbed may then be consolidated with a roller. At maturity, combine harvesting takes place with simultaneous chopping of straw (WOCAT 2007). Naturally, CA systems vary from country to country, and depend on the size of the farm, the degree of mechanization, the production system, and the affluence of the farmer (Critchley 2009).

While CA has been particularly successful in the medium- and large-scale sectors in the Americas, Australia, and Europe, it can also be applied to smallholder farming in the developing tropics (see WOCAT 2007). However, CA's usual reliance on herbicides means a weed-removal problem for low-income farmers. Furthermore, in many areas with small-scale farmers, availability of mulch is a constraint—crop stover, for example, has a high opportunity cost as livestock feed. Thus, CA's wider applicability in Africa has been questioned (Giller et al. 2009), and a similar problem pertains in many parts of Asia (e.g., India: see Bhan and Behera 2014).

Conservation agriculture provides benefits in terms of climate change mitigation.

Conservation agriculture provides benefits in terms of climate change mitigation. Undoubtedly, less fossil fuel is required in land preparation, which reduces emissions, and the buildup in organic matter within the topsoil—because it is not turned and exposed to oxygen, and because mulch helps increase organic matter—can be significant.

The Intergovernmental Panel on Climate Change (2014c) classes "reduced tillage intensity; residue retention" as having "high technical potential" for mitigation of greenhouse gases.

Specialized direct drill machinery is required for conservation agriculture.

Robbins (2011) quotes a widely accepted figure of around 0.30–0.65 t/ha per year of carbon potentially sequestered under low or medium levels of management (he does not specifically refer to CA, but this system fits his description). However, these figures have recently been challenged by a group of authors who hold that "the quantity of additional organic carbon in soil under no-till is relatively small" (Powlson et al. 2014), and nowhere close to the levels quoted by Robbins (2011) and other authorities. However, they do not dispute that some carbon is sequestered under such systems, and it is important to note that their argumentation takes issue with a UNEP report on greenhouse gas emissions that focused on no-till rather than the full conservation agriculture package (UNEP 2013). Thus, significantly, they do not fully account for mulching, which is a key component of increasing carbon in the soil under CA systems.

Homegardens: Mixing and Matching—Integrating and Intensifying

Homegardens generally represent the most biodiverse (and agrobiodiverse) location within a farm, and the most intensively cultivated and integrated in terms of production systems. Animals form an integral part, making use of food leftovers thus reducing wastage and turning it into manure.

While the most diverse and productive forms of homegardens are found in the humid tropics, they are characteristic of perhaps the majority of rural households worldwide—they provide excellent examples of "micro-environments unobserved" (Chambers 1990). Indeed, when listing examples of microclimates, Chambers (1990) begins with "homegardens, also known as homestead, household, kitchen, or dooryard gardens."

Homegardens generally represent the most biodiverse (and agrobiodiverse) location within a farm, and the most intensively cultivated and integrated in terms of production systems (Critchley 2009). Animals form an integral part also, making use of food leftovers thus reducing wastage and turning it into manure as a valued by-product. The ubiquitous and omnivorous household pig is characteristic of the PRC, and almost everywhere, chickens scavenge and produce a nutritious supply of eggs and meat. There is a concentration of water (runoff from roofs and compounds; wastewater), organic matter (from animals and crop processing) and thus fertility (often through compost heaps), human activity, integration-cum-recycling of resources, and ingenuity.

Homegardens are usually connected to tracks and roads; thus, in contrast to crops produced in distant fields, marketing of produce involves little transport costs. Rural women have a significant influence on homegardens. What we are realizing now is that homegardens can also constitute important climate-resilient nuclei for rural households. Of course, not all households conform to the high standards implicit in the foregoing. Some, in contrast, are notable for accumulation of trash, including toxic waste such as batteries, agrochemicals, and plastics.

In the classic Asian context, homegardens are a form of agroforestry: multistrata, multispecies, highly intensive mixtures around the homestead (Critchley 2009). A homegarden is defined by

Hoogerbrugge and Fresco (1993) as “a small-scale, supplementary food production system by and for the household members that mimics the natural, multi-layered ecosystem.”

Homegardens are visually striking. In 1901, Gelpke (translated from the original Dutch) wrote:

> He who enters a mixed garden with a botanical eye, sees before him a diversity of plants of which the uninitiated can form no idea...that wealth of vegetation is all the more striking when the observer regards it from an economic point of view. He sees palms, bamboos, bananas...all seemingly much alike with various winding plants clinging to them.

Terra (1953) describes the “mixed-garden horticulture” of Java in great detail (beginning, in fact, with the above quote from Gelpke 1901). He traces such gardens to almost the whole of Southeast Asia, including Burma (Myanmar), Ceylon (Sri Lanka), Siam (Thailand), Cambodia, Malaya (Malaysia), and all over Indonesia; and then notes that such gardens are evident in Polynesian and Micronesian regions, and that “they are reported also from the Mexican west coast and from the West Indies.” Limiting himself to the lower plains of Java, he lists the botanical names of more than 50 varieties of common fruit trees grown in mixed gardens. His exhaustive list includes nut-bearing trees, trees grown for their leaves to be used as vegetables, trees for spices, etc.

There are multiple types of homegardens: they are very complex systems with a sophisticated structure and a large number of components.

WOCAT (2007) describes an example from the Philippines locally termed *maramihang pagtatanim*, which is a particular mixture based on multistorey cropping of a wide variety of specific trees, perennial shrubs, and annuals that has been devised by agronomists and promoted (successfully) locally. This links well to Raintree and Warmer’s comment that scientific approaches to agroforestry can mainly contribute to homegardens (in Asia) by introducing improved tree species (Raintree and Warner 2015).

While Terra (1953) does not talk of livestock, a fascinating article from more recent times, also focusing on Java, investigates the apparent overfeeding of stall-fed goats (Tanner et al. 2001). They deduced that the minor incremental gain from the excess fodder which was being fed to the animals was illogical—from the point of view of labor or economics—unless manure production was taken into account. Then, it became clear that the housed goats were being used, effectively, as manure-production units, converting fodder from field margins and roadsides into fertile dung to be applied to crops.

There are multiple types of homegardens: they are very complex systems with a sophisticated structure and a large number of components, and each farm unit is “a specialized entity in itself” (Fernandez and Nair 1986). Thus, it is practically impossible to classify homegardens or describe a “typical” example. The same authors, however, state that homegardens are “characterized by high species diversity and usually 3–4 vertical canopy strata.”

Maize stover acts as mulch beneath a wheat crop.

In Tanzania, for example, tall trees such as *Cordia africana* and *Olea welwischii* form the top strata, while shorter trees such as *Tectona grandis* and *Trema guineensis*—and currently the popular alien species (from Australia) *Grevillea robusta*—characterize the second strata. Shrubs and bushes, including coffee, are found in the third strata, while the lowest comprises root crops, taro or "cocoyam" (*Colocasia antiquorum*), for example, and vegetables. In drier regions, while there may not be the same well-defined vertical strata, species diversity and the presence of trees are still characteristic.

Homegardens in their various forms are suitable worldwide—though, naturally, their composition, species diversity, and size depend closely on the particular situation. Their importance in terms of food production is often underestimated: in Sri Lanka, almost half of the agricultural land is under these systems, while in Java, Indonesia, the proportion of homegardens to farmland generally is in the region of 20%–50% (Critchley 2009). Raintree and Warner (2015) suggest that flying over Java, the "forests" are actually contingent homegardens, which gives an evolutionary clue that these are the most efficient form of land use in this densely populated, rainfed zone. Taking the evolutionary argument one step further, it has even been argued that urban agriculture "is basically the homegarden migrating from its rural origins together with the people that used to tend it there" (Critchley et al. 2008).

Hoogerbrugge and Fresco (1993) point out that production data are rarely reported and anyway are difficult to compare. They quote figures of up to 1.5 kilograms of fresh produce per day from plots of 18 square meters in a Thai homegarden, and state that plantain production may be five times as high as the same crop in a plantation. The same authors quote Ensign et al. (1985) as having calculated that 80% of staples, 80% of fruit, and 60% of leaf vegetables come from homegardens. As well as their productivity, Young (1997) notes their effectiveness in controlling erosion in an area (around the house) where considerable runoff is generated, and if not harvested

This Javanese home garden is multistorey and highly productive.


A "village of homegardens" in India (left) is irrigated by a managed wastewater system (right).

through channels for production (some farmers indeed use drainage channels to convey manure to fruit trees) can lead to gullying and sheet wash in surrounding fields.

Fernandez and Nair (1986) lamented the fact that, because of their complexity, these important systems had hitherto been ignored by the scientific and development community and deserved more serious attention. Since the turn of the 20th century, the development community has certainly focused more attention on homegardens—especially on vegetable production, often under organic regimes, and zero-grazed dairy cows. Lok (2001) points out one fundamental problem: that understanding and working with homegardens has often been problematic because of their unique and complex structure "which can make them resemble a chaotic collection of vegetation and a few animals."

Homegardens represent a highly productive, strategically important, and potentially climate-resilient nucleus within a farm.

Research and development activities in homegardens remain weak. It is high time that this changed, especially since homegardens represent a highly productive, strategically important, and potentially climate-resilient nucleus within a farm. It is not without significance that homegardens can be said to form the smallest unit for a "nested landscape approach"—the baby Russian doll in the center of the *matryoshka*.

6 Implications for Investment Opportunities: Investing in a Greener Landscape

Sustainable land management is undeniably essential in addressing the widespread and growing issue of land degradation. Its adoption requires the coordinated and collaborative involvement and support of various stakeholders, including local and national governments, nongovernment organizations, scientific institutions, and both multilateral and bilateral development partners. At the local level, investments in sustainable land management (SLM) practices can focus on increasing income, improving food security, and reducing poverty. At the landscape level, different scales of SLM can be addressed. At the national and global levels, appropriate policies help alleviate hunger and malnutrition, as well as reduce poverty, while simultaneously protecting natural resources and ecosystem services and preserving cultural heritage.

According to the Economics of Land Degradation Initiative, investment opportunities to prevent or address land degradation not only help to improve local livelihoods, reduce hunger and poverty, and restore natural ecosystems, but they can also be financially rewarding (ELD 2013). To provide key information for making decisions on where investments can best be made, and which SLM practices have the best potential to spread, areas with land degradation and good SLM practices need to be identified and the impacts on ecosystem services need to be assessed—e.g., through initiatives such as the World Overview of Conservation Approaches and Technologies (www.WOCAT.net). This is where mapping of degradation and conservation coverage becomes essential both as a prerequisite for proper planning of investments in SLM and as evidence of the extent and effectiveness of achievements that further stimulate SLM practices.

National Level

Land degradation impacts are most keenly felt in areas with widespread poverty and fragile ecosystems whose population predominantly depends on land and its resources for their livelihood. Smallholder farmers, particularly in these ecologically fragile areas, cultivate a large fraction of the land for crops upon which they depend. But they sorely lack knowledge, resources, and access to appropriate technologies and methods to sustainably manage land and its resources. SLM investments can help farmers increase food security and improve livelihoods while providing important ecological services, notably food production, conservation of biodiversity, and preservation of natural landscapes.

Because of the importance of SLM to rural livelihoods, national governments are under an obligation to allocate adequate and ample resources for the development and promotion of soil and water conservation technologies, including both indigenous and innovative practices, for combating soil erosion and nutrient depletion, improving water conservation and water infrastructure, increasing yield and productivity, and addressing climate change. Investments in better soil management are vital to improving soil fertility and water availability and quality. The role of soils in climate change mitigation and adaptation is an urgent issue of concern and one that is inadequately understood, acknowledged, or addressed.

Given that farmers play a key role in maintaining the ecosystems of rural areas, national government, together with other investors—notably the private sector—can, and should, provide compensation for the ecosystem services these farmers ensure. Compensation can consist of innovative schemes to reward upstream land users for protecting watersheds and even for conserving agrobiodiversity.

Another key area for investment by the national government is the preservation of cultural and natural landscapes. In specific cases, as we have seen, these may still be in current use for agricultural purposes. Many cultivated landscapes still support abundant biodiversity, as among the fields there are gene pools in which endemic plants are protected. Moreover, cultural and natural landscapes have value for tourism and ecotourism, such as the rice terraces in Banaue, Philippines. Unfortunately, escalating migration of youth from rural areas to areas of economic opportunity (cities and other countries) is also contributing to the decline of these landscapes and social structures, primarily due to lack of labor needed for their upkeep.

Successful implementation of SLM often requires close cooperation between neighbors and members of a village community as well as other various actors, including farmers, extension workers, researchers, and decision makers. Providing information, imparting knowledge, and exchanging experience play a key role, which the national government can facilitate. Information and training are vital if SLM practices are to move forward.

As many SLM practices entail long-term investments that require greater tenure security for widespread adoption, national legislation needs to effectively incorporate customary land tenure into land policies to create an enabling environment. In many Asian countries, however, land registration has made poor progress due to weak capacity to conduct cadastral surveys. National governments, therefore, need to find effective ways of making land management systems accountable and protective of land rights, thus ensuring improvement of tenure systems for the rural poor.

International Support

International support for SLM, using a landscape approach, can be channeled through a wide range of investment opportunities, from capacity building (involving training, information dissemination, communication, and making available inputs) to innovative SLM technologies and approaches (such as conservation agriculture, integrated land and water management, and sustainable forest management), as well as advisory services for institutional and policy reforms.

Projects and programs supported and financed by international development partners, such as ADB, FAO, the Global Environment Facility (GEF), and the World Bank, among others, can serve as valuable sources of best practices and lessons learned from diverse ecosystems. The GEF, for example, has embarked on several projects that address transboundary land degradation issues. The FAO gathers and disseminates data and information on agriculture, land, water, fisheries, and forestry resources through its member countries and field projects. WOCAT hosts a rich database. There is, thus, a constant need for investing in the documentation and evaluation of SLM practices and their impacts on ecosystem services, so that such knowledge can be made broadly available for land users, decision makers, and other relevant stakeholders.

International support is also sorely needed in the development and adoption of technologies for SLM, particularly in countries where there is a generally weak capacity to develop and disseminate SLM technologies. Also, with the increasing interest in payment for ecosystem services (PES), investments can be channeled through global mechanisms to finance, for example, carbon sequestration in soils. Besides PES, there are other economic instruments to reverse land degradation trends, which include subsidies, voluntary payments for environmental conservation, and access to microfinance and credit.

Another way for the international community to support the adoption of SLM is by sponsoring or organizing international forums where governments and other interested stakeholders come together to discuss their concerns about land degradation, and agree on mutually beneficial ways to sustainably use and manage land and other natural resources.

When investments facilitating SLM are established and implemented in cooperation with all concerned stakeholder groups, these will contribute to the preservation and strengthening of ecosystem functions through a greener landscape.

References

Agarwal, A., and S. Narain, eds. 1997. *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems*. New Delhi: Centre for Science and Environment.

Agarwal, A., S. Narain, and I. Khurana, eds. 2001. *Making Water Everybody's Business: Practice and Policy of Water Harvesting*. New Delhi: Centre for Science and Environment.

Alcorn, J., and A. Royo. 2015. Best REDD Scenario: Reducing Climate Change in Alliance with Swidden Communities and Indigenous Peoples in Southeast Asia. In M. F. Cairns, ed. *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and Forest Cultivation*. London: Earthscan. pp. 289–306.

Amundson, R., A. Berhe, J. Hopmans, C. Olson, A. Sztein, and D. Sparks. 2015. Soil and Human Security in the 21st Century. Science. 348 (6235): 1261071 DOI: 10.1126/science.1261071

Asian Development Bank (ADB). 2000. *Rural Asia: Beyond the Green Revolution*. Manila. www.adb.org/publications/beyond-green-revolution-overview

ADB. 2010a. *Focused Action: Priorities for Addressing Climate Change in Asia and the Pacific*. Manila. www.adb.org/publications/focused-action-priorities-addressing-climate-change-asia-and-pacific

———. 2010b. *National REDD+ Strategies in Asia and the Pacific: Progress and Challenges*. Manila. www.adb.org/publications/national-redd-strategies-asia-and-pacific-progress-and-challenges

———. 2012. *Green Growth, Resources and Resilience: Environmental Sustainability in Asia and the Pacific*. Manila. www.adb.org/publications/green-growth-resources-and-resilience

———. 2013. *Environment Operational Directions 2013–2020: Promoting Transitions to Green Growth in Asia and the Pacific*. Manila. www.adb.org/documents/environment-operational-directions-2013-2020

———. 2015. *Operational Plan for Agriculture and Natural Resources: Promoting Sustainable Food Security in Asia and the Pacific in 2015–2020*. Manila. www.adb.org/documents/operational-plan-agriculture-and-natural-resources-2015-2020

ADB and World Wide Fund for Nature (WWF). 2012. *Ecological Footprint and Investment in Natural Capital in Asia and the Pacific*. www.adb.org/publications/ecological-footprint-and-investment-natural-capital-asia-and-pacific

Baheranwala, F. 2011. *Joint Forest Management at a Crossroads: Which Direction Now?* Master's thesis. Vrije Universiteit, Amsterdam.

Bai, Z., D. Dent, L. Olsson, and M. Schaepman. 2008. Proxy Global Assessment of Land Degradation. Soil Use and Management. 24 (3). pp. 223–234.

Barker, D., A. Watson, S. Sombatpanit, B. Northcutt, and A. Maglinao. 2004. *Ground and Water Bioengineering for Erosion Control and Slope Stabilisation*. Enfield, New Hampshire: Science Publishers.

Bayrak, M., T. Nam Tu, and P. Burgers. 2015. Formal and Indigenous Forest-Management Systems in Central Vietnam: Implications and Challenges for REDD+. In M. F. Cairns, ed. *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and Forest Cultivation*. London: Earthscan. pp. 319–334.

Beddington, J., M. Asaduzzaman, A. Fernandez, M. Clark, M. Guillou, M. Jahn, L. Erda, T. Mamo, N. Van Bo, C. Nobre, R. Scholes, R. Sharma, and J. Wakhungu. 2011. *Achieving Food Security in the Face of Climate Change: Summary for Policy Makers from the Commission on Sustainable Agriculture and Climate Change*. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Bhan, S. and U. Behera. 2014. Conservation Agriculture in India—Problems, Prospects and Policy Issues. *International Soil and Water Conservation Research*. 2 (4). pp. 1–12.

Bloom, D., P. Craig, and P. Malaney. 2001. *The Quality of Life in Rural Asia*. Manila: ADB. www.adb.org/sites/default/files/publication/28032/quality-life-rural-asia.pdf

Branca, G., L. Lipper, N. McCarthy, and M. Jolejole. 2013. Food Security, Climate Change and Sustainable Land Management. A Review. *Agronomy for Sustainable Development*. 33 (4). pp. 635–650.

Bridges, E., I. Hannan, L. Oldeman, F. Penning de Vries, S. Scherr, and S. Sombatpanit, eds. 2001. *Response to Land Degradation*. New Delhi: Oxford and IBH Publishing.

Bruijnzeel, L., and C. Bremmer. 1989. Highland-Lowland Interactions in the Ganges Brahmaputra River Basin: A Review of Published Literature. International Centre for Integrated Mountain Development (ICIMOD) Occasional Paper No 11. Kathmandu, Nepal.

Cadiz, R.T., Benaires, P.T., and Liwanag, H.V. 2001. Saving the Philippine Dipterocarps. *Canopy International*. 27 (5). p. 2.

Cairns, M., ed. 2015. *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and Forest Cultivation*. London: Earthscan.

Chambers, R. 1983. *Rural Development: Putting the Last First*. New York: Longman.

———. 1990. Microenvironments Unobserved. *Gatekeeper Series*. No. 22. London: International Institute for Environment and Development.

Chinene, V., T. Shaxson, P. Molumeli, and M. Segerros. 1996. *Guidelines to Better Land Husbandry in the SADC Region*. Maseru, Lesotho: Southern African Development Community—Environment and Land Management Sector Coordination Unit (SADC-ELMS).

Convention on Biological Diversity (CBD). 1996. *Decision CBD/COP/III/11—Conservation and Sustainable Use of Agricultural Biological Diversity*. Montreal: Secretariat of the CBD. www.cbd.int/decisions/?id=7107

———. 2004. *The Ecosystem Approach: CBD Guidelines*. Montreal: Secretariat of the CBD. https://www.cbd.int/doc/publications/ea-text-en.pdf

Critchley, W. 2000. *Groundtruthing: New Perspectives on Soil Erosion and Conservation in the Tropics*. PhD Thesis. Vrije Universiteit, Amsterdam.

———. 2007. *Working with Farmer Innovators: A Practical Guide*. Centre for International Cooperation. Free University Amsterdam.

———. 2009. Soil and Water Management Techniques in Rainfed Agriculture: State of the Art and Prospects for the Future. Background Note to World Bank. 2010. Improving Water Management in Rainfed Agriculture: Issues and Options in Water-Constrained Production Systems. *World Bank Other Operational Studies* 13028. Washington, DC: World Bank.

Critchley, W., G. Negi, and M. Brommer. 2008. Local Innovation in "Green Water" Management. In D. Bossio and K. Geheb, eds. Conserving Land, Protecting Water. *Comprehensive Assessment of Water Management in Agriculture Series*. Vol. 6. UK: CAB International. pp. 107–119.

Critchley, W., C. Reij, and T. Willcocks. 1994. Indigenous Soil and Water Conservation: A Review of the State of Knowledge and Prospects for Building on Traditions. *Land Degradation and Rehabilitation*. 5 (4). pp. 293–314.

Critchley, W., and K. Siegert. 1991. *Water Harvesting*. Rome: Food and Agriculture Organization of the United Nations.

Critchley, W., S. Sombatpanit, and S. Medina. 2001. Uncertain Steps? Terraces in the Tropics. In E. Bridges, I. Hannan, L. Oldeman, F. Penning de Vries, S. Scherr, and S. Sombatpanit, eds. *Response to Land Degradation*. New Delhi: Oxford and IBH Publishing. pp. 325–338.

Critchley, W., S. Sombatpanit, and G. Schwilch. 2004. Vegetative Barriers: Green Belts or a Waste of Space? In D. Barker, A. Watson, S. Sombatpanit, B. Northcutt, and A. Maglinao. *Ground and Water Bioengineering for Erosion Control and Slope Stabilization*. Enfield, New Hampshire: Science Publishers. pp. 355–364.

Damrosch, R., and T. Frederic. 2009. Global Overview of Conservation Agriculture Adoption. Paper presented to the IV World Congress on Conservation Agriculture. New Delhi, India. February.

De Graaf, J., J. Cameron, S. Sombatpanit, C. Pieri, and J. Woodhill, eds. 2007. *Monitoring and Evaluation of Soil Conservation and Watershed Development Projects*. Enfield, New Hampshire: Science Publishers.

Derpsch, R., and T. Friedrich. 2009. Development and Current Status of No-Till Adoption in the World. Proceedings on CD-ROM. 18th Triennial Conference of the International Soil & Tillage Research Organization (ISTRO), Izmir, Turkey, 15–19 June.

Doolette, J. and W. Magrath. 1990. Watershed Development in Asia: Strategies and Technologies. World Bank Technical Paper No. 127. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/1990/07/440550/watershed-development-asia-strategies-technologies

Douglas, M. 1994. *Sustainable Use of Agricultural Soils: A Review of the Prerequisites for Success or Failure*. Bern, Switzerland: Centre for Development and Environment, University of Bern.

Dove, M. 2015. The View of Swidden Agriculture by the Early Naturalists, Linnaeus and Wallace. In M. F. Cairns, ed. *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and Forest Cultivation*. London: Earthscan. pp. 3–24.

Economics of Land Degradation (ELD) Initiative. 2013. *The Rewards of Investing in Sustainable Land Management*. Interim Report for the Economics of Land Degradation Initiative: A Global Strategy for Sustainable Land Management. http://eld-initiative.org/ http://inweh.unu.edu/wp-content/uploads/2014/05/ELD-Interim-Report-Web-Version4.pdf

Economist (The). 2013a. Special Report: Biodiversity. 14 September. www.economist.com/news/special-report/21585091-biodiversity-once-preoccupation-scientists-and-greens-has-become-mainstream

———. 2013b. Water in China: Desperate Measures. 12 October. www.economist.com/news/leaders/21587789-desperate-measures

Ensign, B., G. Freaks, and S. Sangers. 1985. *Homegardens and Home Gardening in the Matera District: The Present Situation and Future Prospects*. Master of Science thesis. Social Science and Economics Dept., University of Leiden, Netherlands.

Farrington, J., C. Turton, and A. James, eds. 1999. *Participatory Watershed Development: Challenges for the Twenty-First Century*. New Delhi: Oxford University Press.

Food and Agriculture Organization of the United Nations (FAO). Conservation Agriculture. Agriculture and Consumer Protection Department. Rome. www.fao.org/ag/ca/

———. Global Land Degradation Information System (GLADIS). Rome. www.fao.org/nr/lada/index.php?option=com_content&view=article&id=161&Itemid=113&lang=en

———. 2007. *SARD and Scaling-up of Good Practices*. Sustainable Agriculture and Rural Development (SARD) Policy Brief 21. Rome.

———. 2008. *Investing in Sustainable Agricultural Intensification*. The Role of Conservation Agriculture: A Framework for Action. Rome. www.fao.org/ag/ca/doc/proposed_framework.pdf

———. 2010a. *"Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. Rome. www.fao.org/fileadmin/user_upload/newsroom/docs/the-hague-conference-fao-paper.pdf

———. 2010b. *The State of the World's Land and Water Resources for Food and Agriculture (SOLAW)*. Rome.

———. 2013a. *Land Degradation Assessment in Drylands: Methodology and Results*. Land Degradation Assessment in Drylands (LADA) Project. Rome. www.fao.org/3/a-i3241e.pdf

———. 2013b. *Climate-Smart Agriculture Sourcebook*. Rome.

FAO, International Fund for Agricultural Development and World Food Programme. 2014. *The State of Food Insecurity in the World 2014: Strengthening the Enabling Environment for Food Security and Nutrition*. Rome. www.fao.org/3/a-i4030e.pdf

FAO AQUASTAT. Conservation Agriculture Adoption Worldwide. www.fao.org/ag/Ca/6c.html

Fernandez, E., and P. Nair. 1986. An Evaluation of the Structure and Function of Tropical Homegardens. International Council for Research in Agroforestry (ICRAF) Working Paper No. 38. Nairobi, Kenya.

Garrity, D., M. Stark, and A. Mercado. 2004. Natural Vegetative Strips: A Bioengineering Innovation to Help Transform Tropical Smallholder Conservation. In D. Barker, A. Watson, S. Sombatpanit, B. Northcutt, and A. Maglinao. *Ground and Water Bioengineering for Erosion Control and Slope Stabilization*. Enfield, New Hampshire: Science Publishers. pp. 263–270.

Gelpke, S. 1901. Naar aanleiding van (With reference to) *Staatsblad*. 1876 (110). Batavia.

Giller, K., E. Witter, M. Corbeels, and P. Tittonell. 2009. Conservation Agriculture and Smallholder Farming in Africa: The Heretics' View. *Field Crops Research*. 114 (1). pp. 23–34.

Global Environment Facility (GEF). Global Environmental Benefits. https://www.thegef.org/documents/global-environmental-benefits

———. 2015. *Sustainable Land Management Financing in the GEF: A Primer for the Sixth Replenishment Phase (GEF-6)*. Washington, DC.

Goddard, T., M. Zoebisch, Y. Gan, W. Ellis, A. Watson, and S. Sombatpanit, eds. 2007. *No-Till Farming Systems*. World Association of Soil and Water Conservation (WASWC) Special Publication No. 3. Bangkok: WASWC.

Grimshaw, R., and L. Helfer, eds. 1995. Vetiver Grass for Soil and Water Conservation, Land Rehabilitation, and Embankment Stabilization: A Collection of Papers and Newsletters Compiled by Vetiver Network. World Bank Technical Paper No. 273. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/1995/12/696874/vetiver-grass-soil-water-conservation-land-rehabilitation-embankment-stabilization-collection-papers-newsletters-compiled-vetiver-network

Harvey, C. Chacon, C. Donatti, E. Garen, L. Hannah, A. Andrade, L. Bede, D. Brown, A. Calle, J. Chara, C. Clement, E. Gray, M. Hoang, P. Minang, A. Rodriguez, C. Seeberg-Elverfeldt, B. Semroc, S. Shames, S. Smukler, E. Somarriba, E. Torquebiau, J. van Etten, and E. Wollenberg. 2014. Climate-Smart Landscapes: Opportunities and Challenges for Integrating Adaptation and Mitigation in Tropical Agriculture. *Conservation Letters*. 7 (2). pp. 77–90.

Hellin, J. 1999. Soil and Water Conservation in Honduras: Addressing Whose Reality? *AgREN Newsletter*. No 40. Overseas Development Institute. London, UK.

———. 2006. *Better Land Husbandry: From Soil Conservation to Holistic Land Management*. Enfield, New Hampshire: Science Publishers.

Henry, B., and B. Murphy. 2014. *Sustainable Land Management and Its Relationship to Global Environmental Benefits and Food Security*. Synthesis report for the Global Environment Facility. Washington, DC.

Hoogerbrugge, I., and L. Fresco. 1993. Homegarden Systems: Agricultural Characteristics and Challenges. Gatekeeper Series. No. 39. London: International Institute for Environment and Development.

Howes, S., and P. Wyrwoll. 2012a. Asia's Wicked Environmental Problems. *ADBI Working Paper Series*. No. 348. Tokyo: Asian Development Bank Institute. https://www.adb.org/sites/default/files/publication/156203/adbi-wp348.pdf

———. 2012b. Climate Change Mitigation and Green Growth in Developing Asia. *ADBI Working Paper Series*. No. 369. Tokyo: Asian Development Bank Institute. https://www.adb.org/publications/climate-change-mitigation-and-green-growth-developing-asia

Hudson, N. 1971 and 1981 second edition. *Soil Conservation*. London: B. T. Batsford Limited.

———. 1991. A Study of the Reasons for Success or Failure of Soil Conservation Projects. FAO Soils Bulletin. No. 64. Rome: Food and Agriculture Organization of the United Nations. www.fao.org/docrep/t0487e/t0487e00.HTM

———. 1992. *Land Husbandry*. London: B. T. Batsford Limited.

Hurni, H. 1986. *Guidelines for Development Agents on Soil Conservation in Ethiopia*. Community Forests and Soil Conservation Development Department, Ministry of Agriculture. Addis Ababa, Ethiopia.

———. 1996. *Precious Earth: From Soil and Water Conservation to Sustainable Land Management*. Bern, Switzerland: International Soil Conservation Organization and Centre for Development and Environment.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R. K. Pachauri, and A. Reisinger (eds.)]. Geneva, Switzerland.

———. 2014a. Summary for Policymakers. In Climate Change 2014: *Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [C. Field et al. (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press. pp. 1–32.

———. 2014b. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R. K. Pachauri, and L. A. Meyer (eds.)]. Geneva, Switzerland.

———. 2014c. Summary for Policymakers. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [O. Edenhofer et al. (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press. pp. 1–32.

International Food Policy Research Institute. 2002. *Green Revolution: Curse or Blessing?* Washington, DC. www.ifpri.org/sites/default/files/publications/ib11.pdf

International Union for Conservation of Nature. Ridge to Reef. https://www.iucn.org/theme/water/our-work/ridge-reef

Landscapes for People, Food and Nature in Africa. 2014. *The African Landscapes Action Plan*. Proceedings of the Landscapes for People, Food and Nature in Africa Conference. Nairobi. 1–3 July.

Larson, A., D. Barry, G. Dahal, and C. Colfer, eds. 2010. *Forests for People: Community Rights and Forest Tenure Reform*. London: Earthscan.

Li, H., M. Xie, and J. He. 2014. *Exchanging Experience with Conservation Agriculture: Towards Climate Resilience*. Washington DC: World Bank.

Lok, R. 2001. A Better Understanding of Traditional Homegardens through the Use of Locally Defined Management Zones. *Indigenous Knowledge and Development Monitor*. 9 (2). pp. 14–19.

Lundgren, B. 1982. Introduction (Editorial). What is Agroforestry? *Agroforestry Systems*. 1. pp. 3–6.

Lundgren, L., and G. Taylor. 1993. *From Soil Conservation to Land Husbandry: Guidelines Based on SIDA's Experience*. Stockholm: Swedish International Development Cooperation Agency.

McKenzie, F., and J. Williams. 2015. Sustainable Food Production: Constraints, Challenges and Choices by 2050. Food Security. Published online 12 March. http://hdl.handle.net/1885/13137

McNeely, J., and S. Scherr. 2003. *Ecoagriculture: Strategies to Feed the World and Save Wild Biodiversity*. Washington, DC: Island Press.

Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: A Framework for Assessment*. Washington, DC: Island Press.

Minang, P., M. van Noordwijk, O. Freeman, C. Mbow, J. de Leeuw, and D. Catacutan, eds. 2015. Climate-Smart Landscapes: *Multifunctionality in Practice*. Nairobi: World Agroforestry Centre (known as the International Centre for Research in Agroforestry [ICRAF] before 2002).

Molden, D., ed. 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. London: Earthscan, and Colombo: International Water Management Institute.

O'Connell, D., B. Walker, N. Abel, and N. Grigg. 2015. *The Resilience, Adaptation and Transformation Assessment Framework: From Theory to Application*. Australia: Commonwealth Scientific and Industrial Research Organisation (CSIRO). www.stapgef.org/stap/wp-content/uploads/2015/03/CSIRO-STAP-Resilience-Adaptation-Transformation-Assessment-Framework-Report.pdf

Organisation for Economic Co-operation and Development (OECD). 2011. *Towards Green Growth*. OECD Green Growth Studies. Paris: OECD Publishing.

Otsuka, K. 2001. Population Pressure, Land Tenure, and Natural Resource Management. *ADBI Working Paper Series*. 16. Tokyo: Asian Development Bank Institute. www.adb.org/sites/default/files/publication/157197/adbi-rp16.pdf

Palmer, J., and G. Laquihon. 2004. Nitrogen-Fixing Contour Hedgerows as a Sustainable Soil and Water Conservation Practice: The SALT Experience. In D. Barker, A. Watson, S. Sombatpanit, B. Northcutt, and A. Maglinao. *Ground and Water Bioengineering for Erosion Control and Slope Stabilization*. Enfield, New Hampshire: Science Publishers. pp. 197–205.

Pearce, F. 2012. *Turning Point: What Future for Forest Peoples and Resources in the Emerging World Order?* Washington, DC: Rights and Resources Initiative. www.rightsandresources.org/documents/files/doc_4701.pdf

People's Republic of China (PRC)-Global Environment Facility (GEF) Partnership on Land Degradation in Dryland Ecosystems, and China-Land Degradation Assessment in Drylands (LADA). 2008. *Best Practices for Land Degradation Control in Dryland Areas of China*. Beijing: China Forestry Publishing House. www.gefop12.cn/data/upload//month_201404/BestPracticesforLandDegradationControlinDrylandEcosystemsofChina_lVsDkl.pdf

PRC–GEF Partnership on Land Degradation in Dryland Ecosystems, Ministry of Finance of the PRC, and State Forestry Administration. 2014. *Integrated Strategy for Sustainable Land Management in Western PRC (2014–2023)*. Beijing: Central Project Steering Committee, Central Project Coordination Office, and Central Project Management Office.

Powlson, D., C. Stirling, M. Jat, B. Gerard, C. Palm, P. Sanchez, and K. Cassman. 2014. Limited Potential of No-Till Agriculture for Climate Change Mitigation. *Nature Climate Change*. 4. pp. 678–683. www.nature.com/nclimate/journal/v4/n8/full/nclimate2292.html

Radstake, F., M. Ariens, H. Luna, and J. Quitazol-Gonzalez, eds. 2010. *Dryland Ecosystems: Introducing an Integrated Management Approach in the People's Republic of China*. Manila: ADB. www.adb.org/publications/dryland-ecosystems-introducing-integrated-management-approach-peoples-republic-china

Raintree, J., and K. Warner. 2015. Agroforestry Pathways Revisited: Voices from the Past. In M. F. Cairns, ed. *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and Forest Cultivation*. London: Earthscan. pp. 87–121.

Robbins, M. 2011. *Crops and Carbon: Paying Farmers to Combat Climate Change*. London: Earthscan.

Sayer, J., T. Sunderland, J. Ghazoul, J-L. Pfund, D. Shell, E. Meijaard, M. Venter, A. Boedhihartono, M. Day, C. Garcia, C. van Oosten, and L. Buck. 2013. Ten Principles for a Landscape Approach to Reconciling Agriculture, Conservation, and Other Competing Land Uses. Special Feature: Perspective in May's Proceedings of the National Academy of Sciences. *PNAS*. 110 (21). pp. 8,349–8,356.

Secretariat of the Convention on Biological Diversity. 2001. *Handbook of the Convention on Biological Diversity*. London: Earthscan.

Steele, P., G. Oviedo, and D. McCauley, eds. 2007. *Poverty, Health, and Ecosystems: Experience from Asia*. Gland: International Union for Conservation of Nature, and Manila: ADB. www.adb .org/publications/poverty-health-and-ecosystems-experience-asia

Steenwerth, K., A. Hodson, A. Bloom, M. Carter, A. Cattaneo, C. Chartres, J. Hatfield, K. Henry, J. Hopmans, W. Horwath, B. Jenkins, E. Kebreab, R. Leemans, L. Lipper, M. Lubell, S. Msangi, R. Prabhu, M. Reynolds, S. Solis, W. Sischo, M. Springborn, P. Tittonell, S. Wheeler, S. Vermeulen, E. Wollenberg, L. Jarvis, and L. Jackson. 2014. Climate-Smart Agriculture Global Research Agenda: Scientific Basis for Action. *Agriculture & Food Security*. 3 (1). p. 11. www.agricultureandfoodsecurity.com/content/pdf/2048-7010-3-11.pdf

Sunderland, T. 2014. "Landscape Approach" Defies Simple Definition—and That's Good. *Forests News*. Center for International Forestry Research. http://blog.cifor.org/23834/landscape -approach-defies-simple-definition-and-thats-good#.VBV93WPzzVo

Tanner, J., S. Holden, E. Owen, M. Winugroho, and M. Gill. 2001. Livestock Sustaining Intensive Smallholder Crop Production through Traditional Feeding Practices for Generating High Quality Manure-Compost in Upland Java. *Agriculture, Ecosystems and Environment*. 84 (1). pp. 21–30.

Terra, G. 1953. Mixed-Garden Horticulture in Java. *Malayan Journal of Tropical Geography*. 1. pp. 33–43.

Torquebiau, E. 2015. Whither Landscapes? Compiling Requirements of the Landscape Approach. In P. Minang, M. van Noordwijk, O. Freeman, C. Mbow, J. de Leeuw, and D. Catacutan, eds. 2015. Climate-Smart Landscapes: *Multifunctionality in Practice*. Nairobi: World Agroforestry Centre. pp. 21–35.

Twomlow, S., W. Critchley, and L. Winowieki. In preparation. Climate-Resilient Households: A Model for Sub-Saharan Africa.

United Nations Convention to Combat Desertification. 1994. *Final Text of the Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa*. www.unccd.int/Lists/SiteDocumentLibrary/conventionText/conv -eng.pdf

United Nations Environment Programme (UNEP). 2011. T*owards a Green Economy: Pathways to Sustainable Development and Poverty Eradication—A Synthesis for Policy Makers*. http://web .unep.org/greeneconomy/resources/green-economy-report

———. 2013. *The Emissions Gap Report 2013*. Nairobi. www.unep.org/pdf/UNEPEmissionsGapReport2013.pdf

———. 2014. *Building Natural Capital: How REDD+ Can Support a Green Economy*. Nairobi. http://unep.org/resourcepanel/Publications/BuildingNaturalCapitalHowREDD/tabid/132320/Default.aspx

World Bank. Public–Private Partnership in Infrastructure Resource Center. Washington, DC. http://ppp.worldbank.org/public-private-partnership

———. 2006. *Sustainable Land Management: Challenges, Opportunities, and Trade-Offs*. Washington, DC.

———. 2010. *Rehabilitating a Degraded Watershed: A Case Study from China's Loess Plateau*. Washington, DC.

World Commission on Environment and Development. 1987. *Our Common Future*. Oxford: Oxford University Press.

World Overview of Conservation Approaches and Technologies (WOCAT). 2007. *Where the Land is Greener: Case Studies and Analysis of Soil and Water Conservation Initiatives Worldwide*. Bern: Technical Centre for Agricultural and Rural Cooperation, FAO, UNEP, and Centre for Development and Environment. https://www.wocat.net/fileadmin/user_upload/documents/Books/WOOK_PART1.pdf

Wunder, S. 2005. Payments for Environmental Services: Some Nuts and Bolts. Center for International Forestry Research (CIFOR). Occasional Paper No. 42. www.cifor.org/publications/pdf_files/OccPapers/OP-42.pdf

Young, A. 1997. *Agroforestry for Soil Management*. Wallingford, UK: CAB International (in association with ICRAF, Nairobi, Kenya).

Sustainable Land Management in Asia
Introducing the Landscape Approach

The Asian Development Bank has introduced significant changes in the way farmers and other stakeholders view and benefit from evolving approaches to sustainable land management (SLM) practices. Firmly embedded in SLM are the management and climate resilience of natural resources, which can be enhanced and scaled up by adopting a "landscape approach." This publication sets out how the landscape approach can contribute to overcoming major environmental and developmental challenges—focusing on rural areas of Asia and by examining prevalent forms of SLM (namely participatory forest management, terraces, conservation agriculture, and home gardens). This publication seeks to strengthen awareness of the landscape approach and facilitate the integration of its key elements into cooperation programs with its developing members.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to a large share of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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